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PHARYNGEAL DIVERTICULA*

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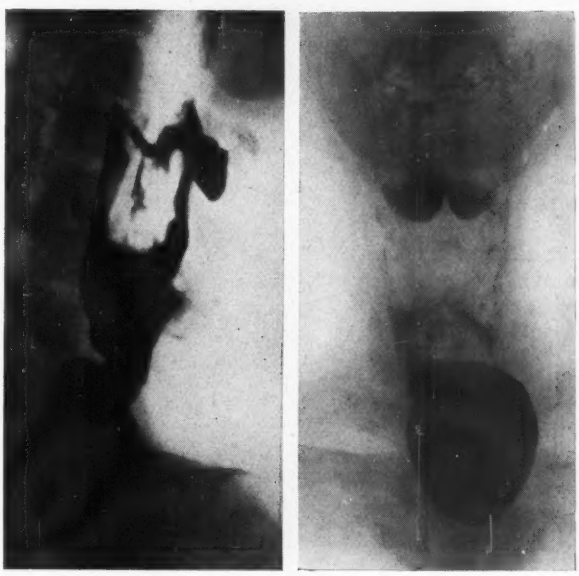
PHARYNGEAL diverticula are among the less common causes of dysphagia, but they may give rise to great disability, and while the diagnosis of the condition is usually simple there is considerable controversy as to the best method of treatment.

The remarks that follow are based on a series of 21 uncomplicated pouches operated on by me, and 2 cases complicated by the development of epithelioma in the pouch.

SURGICAL ANATOMY

These pouches were described by Zenker as "pulsion diverticula" produced by pressure from within the pharynx, as opposed to the relatively unimportant traction diverticula that occur lower in the œsophagus. Their site is a constant one, and is determined by an anatomical weak spot in the posterior wall of the pharynx at its lower end between the transverse and oblique fibres of the cricopharyngeus. The pouch arises as a herniation of mucous membrane through this potential gap and, once started, its gradual increase in size will follow inevitably as a result of the repeated force of deglutition. E. D. Gray (1932) has described the earliest stage of this herniation that is radiologically demonstrable. In a series of 250 consecutive X-ray examinations of the pharynx he saw in 6 patients a pointed barium-filled projection from the posterior pharyngeal wall at the level of the cricoid which is regarded as a potential pharyngeal diverticulum. The initiation of the process of herniation, however, is not easy to explain. Cases have been reported in which some organic obstruction to the œsophagus lower down, such as a fibrous stricture or an intrathoracic thyroid adenoma, has provided a ready explanation of the increase in intrapharyngeal pressure that must surely be the essential factor in causation. But these cases are exceptional, and there were none such in my series. One must assume some spasmodic obstruction on the part of the circular fibres in the upper œsophagus, which raises the intrapharyngeal pressure sufficiently to start the bulge, but there is no solid basis of fact behind this assumption, and it is noteworthy that in the common condition of cardiospasm or achalasia of the cardiac 'sphincter' of the œsophagus, these diverticula do not occur.

I must digress briefly at this point. In 1926 when I reported three diverticula (included in the present series) in the *British Medical Journal* (1926) the late Sir Arthur Hurst wrote to me to point out that one of the illustrations of my article (*Fig.* 97, A)



A B

FIG. 97.—A, Lateral view of pharyngeal pouch showing barium lodged in the vallecula. B, Anteroposterior view of the same pouch with both valleculæ filled with barium.

showed, in addition to the pouch that I had removed, an anterior pharyngo-œsophageal pouch such as he had described shortly before in the *Guy's Hospital Reports* (1925). He enclosed a reprint of his article which was entitled "Anterior Pharyngo-œsophageal Pouch as a Cause of Dysphagia". The article described one case only, but in his letter Hurst said: "Since the publication of my paper I have seen another similar diverticulum which caused no appreciable dysphagia in a patient with duodenal ulcer."

Now it was obvious from the radiographs in Hurst's article that the shadow of his 'pouch' was situated a good 2 in. above the lower end of the pharynx, and in consultation with the late Dr. E. W. Twining I came to the conclusion that his illustrations showed nothing more than barium lodging

* A paper read before the Manchester Medical Society on April 4, 1945.

in the valleculæ between the back of the tongue and the front of the epiglottis. I wrote to Sir Arthur Hurst to this effect, and the following October I received this reply: "I have waited all this time before writing to you again, as I wished to have an opportunity of re-examining the patient with the supposed anterior œsophageal diverticulum. I have now done so, and must candidly confess that I am quite convinced by your arguments. What we took to be a diverticulum was an unusually developed vallecula in front of the epiglottis. It can have had nothing to do with the dysphagia, which is still present in our patient, though no worse than 18 months ago. I am very grateful to you for your long letter, and I shall take the earliest opportunity of correcting my former statements on this subject in the *Guy's Reports*".

Unfortunately the many claims on Sir Arthur Hurst's time and energies never permitted him to publish his promised correction, and last year, after a long struggle against failing health, he passed away.

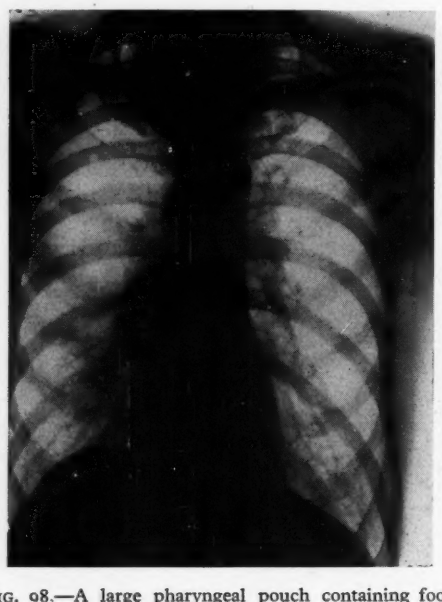


FIG. 98.—A large pharyngeal pouch containing food which was regarded as an intrathoracic goitre.

FIG. 99.—The same pouch filled with barium.

I have, therefore, thought it right to publish this correspondence, and in doing so I should like to acknowledge the great courtesy and the candour with which he admitted his error.

PREDISPOSING CAUSES

1. Age.—Pharyngeal pouches occur as a rule in late middle age. In my series the average age at operation was 60, the oldest patient being 76 and the youngest 36. The patients' statements as to the age of onset of symptoms were too vague for precise calculations, but in most cases symptoms had been present for from 5 to 10 years before operation.

2. Sex.—The condition is commoner in men than in women. In my series of 21 patients with uncomplicated pouches there were 14 men and 7 women. The 2 patients who had pouches complicated by epithelioma were both men. Lotheissen (1931) states that 79 per cent of the patients are males. No other predisposing factor such as heredity or occupation emerges from a study of my series, nor is there any evidence that the chronic cough of bronchitis is an important factor.

SYMPTOMS

Some degree of dysphagia, associated with regurgitation of food, is the most constant symptom, but patients and their friends complain with almost equal frequency of a most disagreeable gurgling noise on swallowing food or even saliva. At times there are attacks of violent coughing and choking when food is regurgitated and begins to enter the glottis. Finally, there is loss of weight. In the early stages the weight may be well maintained, and the symptoms are more an annoyance or inconvenience than a source of ill health. Patients complain that much time is consumed in getting their meals down. Gradually as the pouch enlarges the obstruction to the passage of food into the œsophagus becomes more pronounced, and in a later or neglected case there is progressive emaciation. In some cases a large pouch, when full of food, presents a visible and palpable swelling in the neck, usually to the left side, with both gurgling and regurgitation of food on pressure.

DIFFERENTIAL DIAGNOSIS

Carcinoma of the œsophagus, besides being a much more common cause of dysphagia than pharyngeal pouch, has a similar age and sex incidence. Patients with pharyngeal pouch usually give a much longer history, and though in the later stages they may show progressive emaciation, there is no such pallor from secondary anæmia as accompanies the emaciation caused by œsophageal carcinoma.

Broadly speaking, the differentiation from other causes of dysphagia such as carcinoma, cardiospasm,

and cicatricial stenosis, depends upon X-ray examination with a barium swallow. But occasionally in a straight radiograph of the chest, when a pouch of considerable size is full of food, the shadow in the superior mediastinum may be interpreted as an intrathoracic goitre, as happened in the following case :—

A man aged 51 was referred to me from the medical wards of the Infirmary as a case of intrathoracic goitre with a history of a 12-months' loss of weight, shortness of breath, and difficulty in swallowing. Radiography of the chest (*Fig.* 98) was reported as "very much in favour of retrosternal goitre. The gland is evidently enlarged more to the right". The basal metabolic rate was increased by 41 per cent. The pulse, however, was only 72, there was no lid retraction and no tremor of the hands or perspiration, and he had no dilated veins over the upper sternum and neck. The diagnosis of pharyngeal pouch was suggested by a characteristic gurgling noise when he swallowed saliva, and a barium swallow confirmed the presence of a large pouch (*Fig.* 99).

ASSOCIATION OF PHARYNGEAL POUCH WITH CARCINOMA

In addition to the series of 21 patients with uncomplicated pouches I have had 2 patients with squamous epithelioma developing in an old-standing pouch. A similar case has been recorded by Capps and Dunhill (1933), and Fitzwilliam (1934) described a case of epithelioma arising in a pouch five years after an operation in which the pouch was suspended upwards in the neck by suture without removal.

My first case was a man aged 57 who had had dysphagia for 16 years, and in whom a radiograph 10 years earlier had shown a pouch. Two months before I saw him his dysphagia had become much more urgent, and he had lost weight rapidly since then. Obstruction was now practically complete. A radiograph now showed a filling defect at the neck of the sac, which prevented the barium from entering either the sac or the œsophagus. A gastrostomy was performed, and the presence of a fixed and inoperable epithelioma originating at the neck of the pouch was established. The patient survived the operation 5 months.

The second patient was a man of 78. Forty years before, in the days before X rays, the late Sir Felix Semon had diagnosed a pouch. It had not troubled him greatly until the last few months, when the dysphagia became rapidly worse. He had lost weight quickly and on several occasions had brought up a little blood mixed with frothy expectoration. He complained of recent pain in the left side of the neck. Radiography showed a fairly large pouch with a filling defect at the neck of the sac.

As he was unable to swallow even fluids except with great difficulty, operation was undertaken. Under intratracheal gas and oxygen the pouch was first exposed in the neck, which was adherent both to the spine and the trachea. Excision was plainly impossible. A Witzel gastrostomy was performed. The patient developed hypostatic pneumonia and died in 24 hours. A specimen of the growth was removed post mortem and was a squamous epithelioma.

While we do not know the precise liability to the development of malignant growths in these pouches, their occurrence in a small proportion of old-standing diverticula provides argument for excision of the sac before such a lethal complication can arise.

TREATMENT

In patients with small pouches whose symptoms are only a mild annoyance rather than a serious threat to their life, any question of surgical treatment may well be postponed, and especially if the patient by reason of age or infirmity is a poor operative risk.

Where treatment becomes imperative we have the choice between excision of the pouch and some minor measure designed to secure relief of symptoms without the dangers associated with excision. Of these minor procedures, invagination of the sac into the pharynx would plainly be feasible only for the very small pouches, and even so would be likely, one would think, to cause mechanical embarrassment both to deglutition and breathing. The operation of diverticulopexy, in which the pouch is suspended in an upward direction by suturing it to the hyoid bone or the side wall of the pharynx is said to give complete relief in some cases, but recurrence of symptoms is far too common. It is plain that complete excision of the pouch is the only satisfactory method.

The obvious method of primary excision and suture in one stage fell into some disrepute in the early years of this century on account of the high incidence of leakage, with sepsis and suppurative mediastinitis in some cases leading to a fatal result. It was in order to obviate this risk that Goldmann (1908) introduced the operation of excision in two stages. In the first stage the sac was isolated, ligated, and brought out through the skin incision to the left side of the neck. Ten days later the necrotic sac was extirpated by the thermocautery. Wilkie and Hartley (1922) advocated the Goldmann two-stage operation with a slight modification, but admitted that a fistula could be expected in about 50 per cent of cases.

Lahey (1937), in a paper based on an operative experience of 82 cases and a follow-up study of 53, states that he sticks to the two-stage operation because "we have had such a low mortality with it and because it gives us such a feeling of comfort and security to realize that with it the dangers of deep cervical cellulitis and mediastinitis are eliminated". He had, however, 18 cases that developed a fistula after the second stage and 5 with secondary abscesses. Two patients had a complete recurrence due to inadequate removal of the sac, and 2 others a partial recurrence with some symptoms. One died of uræmia after the first stage and 1 feeble patient had the first stage only performed.

Harrington, discussing Lahey's paper, states that of 227 cases operated on at the Mayo Clinic 47 were done by one-stage and 180 by two-stage technique. Shallow, in the same discussion, described 99 cases operated on by one-stage excision with 4 deaths, none of which were from mediastinitis.

V. Schmieden (1930) advocated the one-stage operation. In 7 cases 3 healed by first intention and 4 developed fistulæ which were of short duration.

My own 21 cases have all been treated by primary excision of the pouch and suture of its neck. There have been no deaths.

I regard the two-stage operation as unnecessary and tedious for both patient and surgeon. Primary resection is, however, a difficult operation and should in my view only be undertaken by those who have

adequate experience of gastric and intestinal resection. The sac should be washed out frequently with mild antiseptics for a few days before the operation and should receive a final wash-out and be emptied by a catheter just before the operation.

I regard endotracheal gas and oxygen or cyclopropane as the anæsthetic of choice, though the operation can be done under local anæsthesia alone. The pouch is exposed by a transverse collar incision at the level of the cricoid cartilage, as for a thyroidectomy, rather than by the more usual but unsightly incision along the anterior border of the left sternomastoid. It is approached more readily on the left side, unless, as sometimes happens, the radiograph shows that the pouch inclines more to the right. The infrahyoid muscles are usually divided

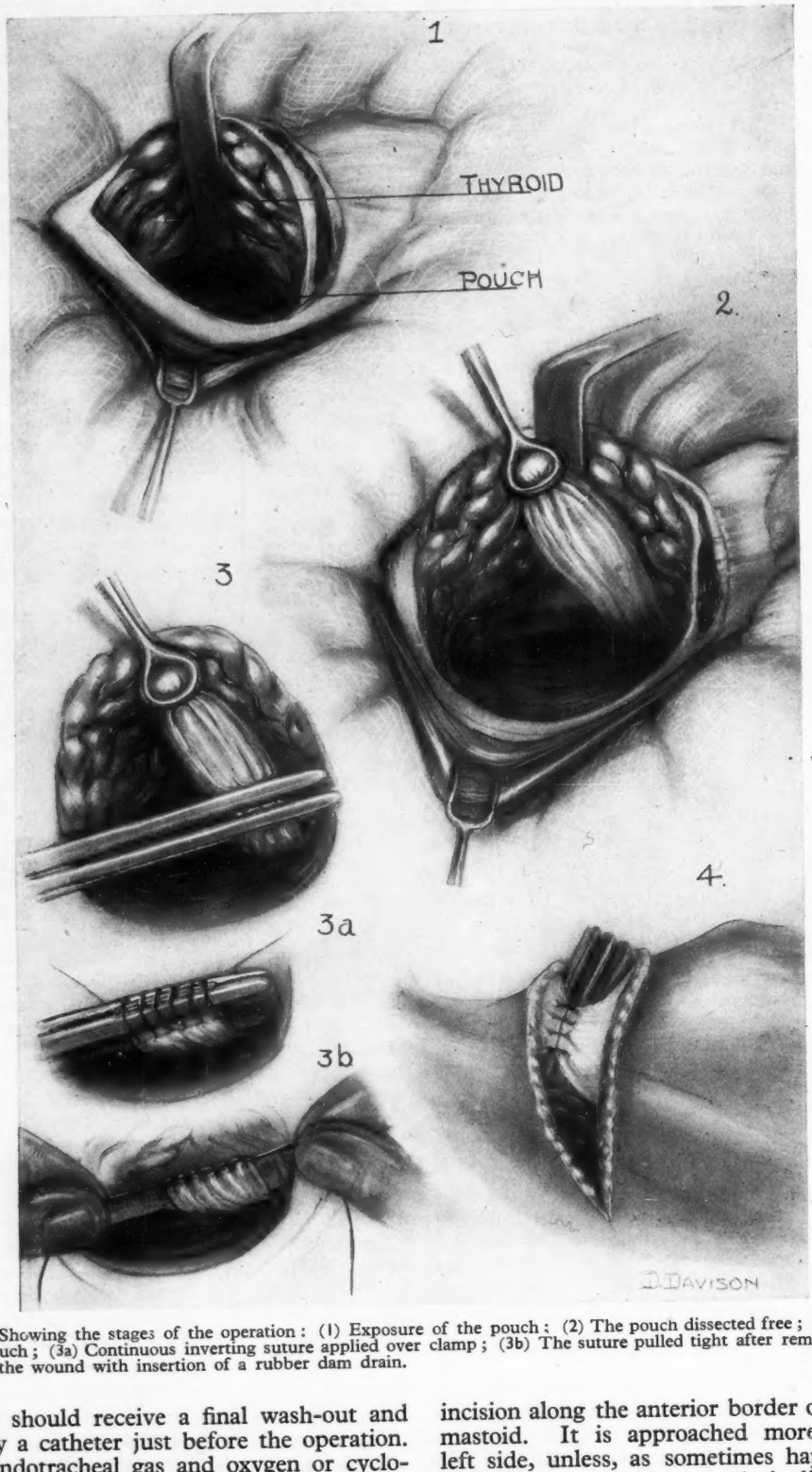


FIG. 100.—Showing the stages of the operation: (1) Exposure of the pouch; (2) The pouch dissected free; (3) Clamps applied near base of pouch; (3a) Continuous inverting suture applied over clamp; (3b) The suture pulled tight after removal of the clamp; (4) Closure of the wound with insertion of a rubber dam drain.

transversely on the left side, and the thyroid gland is thus exposed. The left middle thyroid vein is ligated and divided and by retracting the carotid sheath laterally and the thyroid gland and trachea medially the pouch is identified (*Fig.* 100, 1). It is delivered and dissected clear up to its junction with the pharynx (*Fig.* 100, 2). This dissection is facilitated by traction on the fundus of the pouch with a pair of pile forceps. When the sac is quite free and has been drawn upwards and to the left, the anæsthetist should pass a full-sized œsophageal bougie past the neck of the pouch into the œsophagus. This requires some help from the surgeon in manipulating the tip of the bougie downwards, and the greatest care must be taken lest the bougie should perforate the thin wall of the pouch. It is not absolutely essential, but it is a safeguard against a too drastic excision of the sac which might lead, after suture, to stenosis of the pharynx. Two pairs of Schoemaker colectomy clamps are then applied side by side near, but not too near, to the neck of the pouch (*Fig.* 100, 3). The pouch is now removed by cutting between the clamps with the knife or the diathermy needle, the line of section between the blades of the remaining clamp being then painted with a little pure carbolic acid. A continuous inverting suture of 2/0 chromic gut is then inserted on a small curved needle over the clamp (*Fig.* 100, 3a). The clamp is slid off and the suture at once pulled tight, inverting the edges of the sac (*Fig.* 100, 3b). The same suture is then brought back along the whole length as a secondary invaginating stitch, and tied to the original end. A few further points of interrupted catgut suture are superadded for greater security and the wound closed, leaving a rubber dam drain down to the suture line for 3 or 4 days (*Fig.* 100, 4). An intravenous drip of glucose-saline is advisable for the first 24 hours, with nothing but mouth-washes, but after that the patient may drink sterilized fluids. No solid food is allowed for 8 to 10 days. In all but the largest pouches occurring in debilitated patients, the above technique will prove satisfactory. But where the pouch is a large one and the patient's general condition poor, a preliminary gastrostomy of the Witzel type affords certain advantages. Done 2 or 3 weeks before the pouch is excised, it enables an emaciated patient to put on weight and to stand the excision better. I performed this preliminary gastrostomy on 2 of my patients. In one resection was carried out 2 weeks later. In the other, a septic parotitis followed the gastrostomy and the resection was postponed for 3 weeks. Primary healing followed the resection of the pouch in both cases. In 2 other patients with very large pouches, gastrostomy was performed at the same time as the resection of the pouch. In one of these the pouch, which held 1½ pints of fluid, was so adherent to the arch of the aorta that it tore during delivery from the superior mediastinum. Both of these cases healed by first intention. The gastrostomy tube was removed in all cases as soon as normal swallowing of solid food had been resumed, and the stoma closed spontaneously at once. Two further patients with large pouches developed severe fistulæ 3 or 4 days after resection, and gastrostomy was performed after the fistula formation in order to keep up their nutrition and to help the fistulæ to heal.

Results of Resection.—Of my 21 cases, 16 healed by first intention, 3 developed severe fistulæ that took 9 or 10 weeks to heal, one a slight fistula that healed in 2 days, and 2 developed a slight abscess in the neck without fistula formation that healed in a few days.

It is significant that all the fistulæ and abscesses occurred during the last 5 years, in the period of the war. I attribute this to two factors: (1) The poor quality of the clamps used, owing to the impossibility of replacing them by new ones when the blades were strained, so that they tended to slip off the neck of the pouch; and (2) The inferior quality of the war-time catgut. These mishaps serve to point the moral that unless the suture of the neck is impeccably performed a fistula is likely. Even in these unfortunate cases there was no instance of a dangerous septic mediastinitis.

End-results.—The clinical results have been good in all cases. The patients have regained their weight, and have been uniformly relieved of the unpleasant gurgling in the throat on swallowing. This relief has been no less pronounced in the 3 patients who developed severe fistulæ after operation.

FIG. 101.—Radiograph showing the large pharyngeal pouch.

Radiological examination some time after the operation often shows a small residual pouch, but these do not cause symptoms and do not appear to enlarge progressively.

One strange effect of a resection is worth recording. A male patient, aged 61, with a 17-years' history of dysphagia, who had the largest pouch of the series (*Fig.* 101), holding 1½ pints, had been in the habit of drinking large quantities of neat whisky. The whisky would lie harmlessly in his pouch until such time as he found it convenient to retire and eject its contents, which he did after much practice with great facility. This had gone on for some years, but I was not informed as to his convivial habits at the time of operation, and so could not warn him of the change in his physiology as regards the absorption of alcohol. Within a month of

resuming his accustomed round he developed severe *delirium tremens* and this has been repeated on several occasions since.

SUMMARY

1. A series is described of 21 pharyngeal diverticula treated by one-stage resection and suture.

2. Two cases of pharyngeal diverticula complicated by squamous epithelioma originating in the pouch are recorded.

3. Hurst's anterior pharyngo-œsophageal pouch is explained by barium in the vallecula between the tongue and the epiglottis.

4. The technique and results of the one-stage excision operation are described, and its advantages as compared with resection in two stages are set forth.

REFERENCES

CAPPS, F. C. W., and DUNHILL, T. P. (1933), *Brit. J. Surg.*, **20**, 689.
FITZWILLIAMS, D. C. S. (1934), *Ibid.*, **22**, 186.
GOLDMAN, E. E. (1908), *Beitr. klin. Chir.*, **61**, 741.
GRAY, E. D. (1932), *Brit. J. Radiol.*, **5**, 640.
HURST, A. F. (1925), *Guy's Hosp. Rep.*, 367.
LAHEY, F. H. (1937), *J. Amer. med. Ass.*, **109**, 1414.
LOTHEISSEN, G. (1931), *Klin. Wschr.*, **10**, 73.
MORLEY, J. (1926), *Brit. med. J.*, **1**, 12.
SCHMIEDEN, V. (1930), *Dtsch. Z. Chir.*, **227**, 499.
WILKIE, D. P. D., and HARTLEY, J. N. J. (1922), *Brit. J. Surg.*, **10**, 81.

ACRYLIC RESIN FOR THE CLOSURE OF SKULL DEFECTS

PRELIMINARY REPORT

BY MAJOR J. M. SMALL, R.A.M.C., AND MAJOR M. P. GRAHAM, A.D. CORPS

FROM A MILITARY HOSPITAL FOR HEAD INJURIES

THE problems of repairing skull defects by artificial replacement of the lost bone are by no means new, but are now of particular importance because of the increasing number of patients with traumatic defects requiring surgical intervention. The materials employed for this purpose have been numerous, and have included silver, celluloid, and, more recently, vitallium and tantalum.

Results in the past have not always been satisfactory, and the use of such foreign bodies has been condemned by many surgeons. We consider that the cause of failure has been mainly due to lack of a suitable material. However, with the development of plastics, particularly acrylic resin, the problem has been largely overcome. This communication describes the use of this material in the prosthesis of cranial defects, and a series of 25 cases is recorded in which this method was adopted. Certain general considerations of skull defect closure are also discussed.

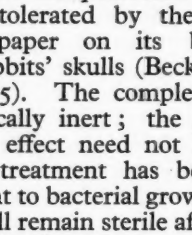
These 25 cases were selected from among 213 requiring closure of skull defects which were operated on at a military hospital for head injuries. The methods used were as follows :—

A. Autogenous Bone-grafts.—	
Rib	50
Ileum	6
Tibia	1
Outer table of skull	1
B. Plastic and Metal Plates.—	
Acrylic resin	25
Tantalum	130

ACRYLIC RESIN

Chemically, acrylic resin is methyl methacrylate and is derived from acrylic acid. The acid was discovered in 1843, but methyl methacrylate was not produced commercially until 1927. It is now used extensively for windshields and astradomes of aeroplanes, and, since the shortage of rubber, for denture bases.

The acrylic resin used in this series was Kallodent (Clear), I.C.I. Ltd. It is supplied as a monomer (a clear liquid) and a polymer (a powder, in appearance like castor sugar), and on mixing the two a soft, snow-like mass is produced. Curing takes place under pressure after packing into a mould, and consists of polymerization by heat. The action is irreversible, and the resulting product is a stable, transparent, colourless, and resinous substance. The formula for the monomer is :—



Properties.—The properties required of the ideal material for 'grafting' will be considered first. The material should be one which will lie indefinitely embedded in the tissues, producing no adverse changes in its surroundings, and will itself remain permanently unaltered—that is, a non-irritating, inert substance. In addition, it must fulfil the requirements of strength, simplicity of technique in processing, and ease and accuracy of manipulation.

These properties are possessed by acrylic resin. That it is well tolerated by the body tissues is shown in the paper on its behaviour when implanted into rabbits' skulls (Beck, Russell, Small, and Graham, 1945). The completely polymerized material is chemically inert; the presence of free monomer and its effect need not be considered if the correct heat treatment has been carried out. It is highly resistant to bacterial growth on its surface, and the interior will remain sterile after many months of external contamination (Drury, Caress, and Corin, 1935). From a physical point of view the important factors are that it is light in weight, having a specific gravity of 1·19, and easily manipulated. The production of the 'graft' is by an adaptation of the methods used in denture construction, so that an exact restoration of lost bone can be achieved with certainty and with the optimum cosmetic result. The perfect fitting thus obtained results in immobility, which is of fundamental importance for the

maintenance of any free graft; in addition, point pressure, with possible resultant bony absorption, is avoided. The strength and resistance to deformity of acrylic resin plates are high, and for this reason it is an admirable material for the restoration of the protecting covering for the brain. Other properties which make acrylic resin particularly suitable for the closure of skull defects are its radiolucency and the fact that it is a bad conductor of heat and electricity.

THE NEED FOR CLOSURE

In considering the repair of skull defects the first question is whether or not it is a necessary procedure. The main indication is usually the desire of the patient to have a solid covering for his brain and so rid himself of the feeling of insecurity so commonly associated with a large skull defect. Intimately connected with this sense of insecurity is the desire for improvement of his personal appearance. It is the patient with the large frontal defect who demands some reconstruction to alleviate these worries; and to prevent a frank anxiety state from developing is of paramount importance in his treatment.

Headaches as an indication for closure must be carefully considered. There are two types of headache commonly relieved by closure of skull defects. The first is local pain at the site of the defect, usually brought on by exertion; this is commonly seen in defects of the temporal or parietal region, possibly due to meningeal vessel distortion caused by pulsation and dural movement. The second is pain referred to the orbits, seen usually in defects in the region of the sagittal sinus, again produced by exertion or change of posture, and almost certainly due to distortion of the sinus and resultant referred pain in the first division of the 5th cranial nerve.

Generalized headache of vague character, described by the patient in a variety of expressive ways, is rarely influenced by skull defect repair. These patients often have other symptoms of the post-traumatic anxiety state, and rarely present themselves with local complaints referable to the skull defect or desire its closure for security or cosmetic reasons: they are more concerned with themselves, and constitute poor subjects for surgical treatment.

There is also a group of patients with skull defects resulting from bone removal at operation in whom closure of the resulting defect can be undertaken at the same operation. This important group is considered under " Operative Defects ".

METHOD OF PERFORMING ACRYLIC 'GRAFTING'

The method here described attempts to replace the missing cranial bone by an acrylic plate which exactly fits the defect and faithfully reproduces the original contour of the skull, thereby giving a perfect cosmetic result.

Pre-operative Considerations.—Apart from general neurological or general surgical aspects of each case, there are certain specific pre-operative considerations. First of all, the condition of the scalp which will overlie the 'graft' or plate is of paramount importance. Whatever length of time has elapsed since the primary operation, a short course of radiant heat and light massage to the scalp in the region of the skull defect should be given preparatory to operation. This will frequently light up a focus of latent infection, should such be present, and will thus help to avoid operation on a skull defect in which sepsis lies hidden in the tissues only to flare up when the operation is performed. In this series of cases repair was not undertaken until at least three months after the scalp had been soundly healed. However, if the scalp is healthy and the above precautions are observed, it has been found that 'grafting' can safely be undertaken in certain cases at a much earlier date.

Many old cases of brain wound have a paper-thin epithelial scar overlying the defect, and radiating scars over a wide area of the scalp. The very thin scar will undergo avascular and pressure necrosis when lying over a graft, and for this reason primary plastic operation on the scalp may be needed first for excising the scar and obtaining full-thickness scalp to cover the graft.

With large defects the making of a plaster moulage which shows the defect and includes the comparable area on the other side of the head may be helpful during the laboratory process in reproducing the correct contour in the 'graft'. It may also be necessary for specially shaped impression trays to be made for use during the operation.

The technique of producing the acrylic plate is an adaptation of the methods used in the construction of dentures, and requires at least four hours' laboratory work in order to produce the finished article. Up to the time of writing, this time factor has entailed a two-stage operation for the repair of cranial defects by this method.

Surgical Procedure.—A scalp flap is utilized to give full exposure of the cranial defect and its adjacent area. With the widespread radiating scars often seen in these cases, this may not be a simple consideration. Great care is needed in planning the incision for the scalp flap in order that all portions of the flap have an adequate blood-supply. Unless this is done the flap margin may undergo necrosis to varying depths, and at best this will leave a wide bluish-white epithelialized scar always devoid of hair and so spoil in part the cosmetic result of the operation. To avoid this marginal necrosis, standard direction of scalp flaps must often be ignored, and a wide-base pedicle must contain the maximum blood-supply obtainable; and at no point should the old scar reach the flap incision.

The margin of the bone defect and about half an inch of adjacent skull around it are cleared of fibrous tissue and pericranium. The fibrous tissue which is in continuity with the pericranium is attached to the dura or fibrous tissue which has replaced a dural deficiency and needs to be cut away from this. A step is then cut with a mallet and chisel right round the bone of the defect margin. The bone removal is about half the skull thickness and from $\frac{1}{4}$ in. to $\frac{3}{8}$ in. in width. Sharp definition of angles and walls should be aimed at, as this will greatly facilitate the production of a firmly fitting acrylic plate. After hæmostasis, an impression of the bony margins of the defect is obtained. When taking the impression, its removal will be facilitated if the bony margins are previously moistened with a trace of sterile liquid paraffin.

The impression material which has been used for this purpose is Zelex. This hydrocolloid material, which is gelatinous calcium alginate, was selected for several reasons. It is easily sterilized in its powder form by autoclaving at 15 lb. pressure. Minimum pressure is necessary in the application of this material to obtain an impression, so that unnecessary pressure on the dura and brain is avoided. Another great advantage is that when set it is elastic and does not therefore get broken or distorted by the presence of any undercuts in the bone margin during withdrawal.

Zelex is prepared immediately before use by mixing the sterilized powder with cold sterile water to the consistency of thick cream. To obtain the impression the prepared material is placed upon a suitable tray, of which varying sizes and shapes should be available; in certain cases a special tray will need to be prepared. This tray must be sufficiently rigid in construction to avoid distortion during the

FIG. 102.—*Case* 6632. Four months after penetrating head injury due to land-mine explosion. Showing left frontal skull defect, 7 × 6 cm. in size, involving supra-orbital margin.

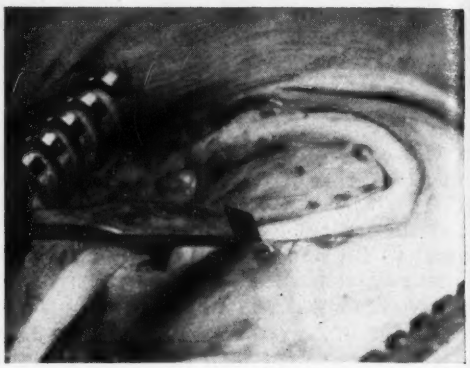


FIG. 103.—*Case* 6632. The margins of the bone defect have been exposed and the 'step' is about to be cut.

FIG. 104.—*Case* 6632. Illustrates the taking of the impression. Excess of the hydrocolloid is seen at the margins of the metal tray.

FIG. 105.—*Case* 6632. Removal of the Zelex impression after setting. The 'step' preparation of the defect margin can be seen.

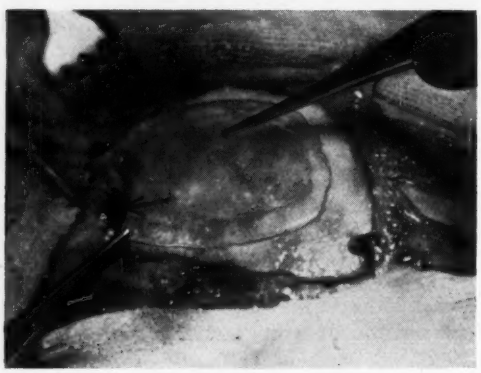


FIG. 106.—*Case* 6632. The acrylic plate in place, showing well the remodelled supra-orbital margin (arrow) and the excellent fit obtained.

FIG. 107.—*Case* 6632. The post-operative result.

taking of the impression, otherwise moulds made from the impression will not be an exact reproduction of the defect. The surface of the chosen tray is coated with hot dental wax, to which the Zelex will adhere. The impression tray with its thick layer of Zelex is pressed steadily into place and then gently held there for four minutes before removal. The impression must include an area of bone at least an inch away from the free margin of the defect, because from this it will be possible to make an acrylic plate which will conform to the curvature of the surrounding bone. On removal the impression is washed free of any blood and immersed in a bowl of saline in which it is conveyed to the laboratory. (*Figs.* 102–105.) A description of the method of processing the acrylic plate is given later.

The scalp is then sutured back into position with a single layer of sutures to await the

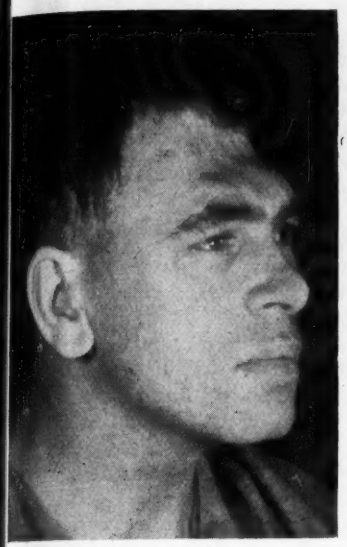


Fig. 108.

Fig. 109.

FIGS. 108–110.—*Case* 9557. Three months after through-and-through shell wound of the frontal region which caused gross comminution of the frontal bones and floor of the anterior fossæ. Lacerated brain and bone fragments were removed and a fascial repair of the dura carried out at the primary operation. Size of skull defect 15 × 9 cm.

Fig. 110.

FIG. 111.—*Case* 9557. Shows acrylic plate in place. Note the perforations.

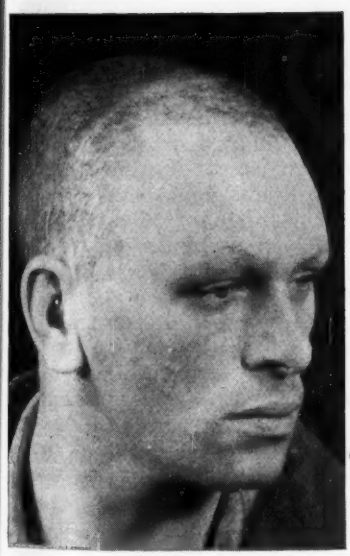


Fig. 112.

Fig. 113.

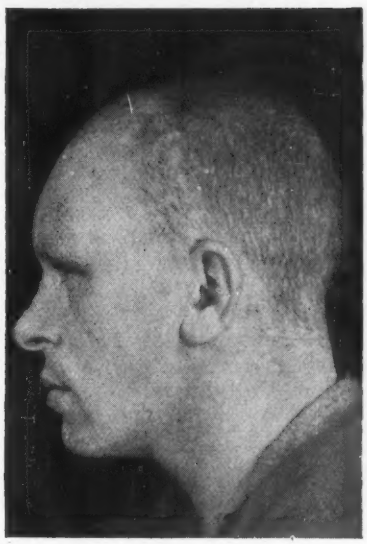


Fig. 114.

FIGS. 112–114.—*Case* 9557. Post-operative photographs and radiograph. *Fig.* 113 shows the step-cut of the bone margin and demonstrates the radiolucency of acrylic resin. (*Lt.-Col. C. A. Calvert's case.*)

The scalp is then sutured back into position with a single layer of sutures to await the

preparation of the 'graft' and its insertion as a second stage.

The insertion of the acrylic plate is usually carried out on the following day, using local anæsthesia. The scalp flap is again turned down, and the acrylic plate, after sterilization by boiling for 30 minutes, is dropped into place; it fits the defect and step exactly. It is held in its seat by suturing one or more pericranial flaps across its surface. Calcium penicillin-sulphamezathine powder should be added to all layers and the scalp closed in the usual two layers without drainage. It has been thought advisable to have several perforations in the plate to allow any possible blood or fluid collections beneath it to escape from the extradural space. (*Figs.* 106–114.)

IMMEDIATE CLOSURE OF OPERATIVE DEFECTS

Some cases with a skull defect have some underlying cerebral pathology requiring treatment. In this series, 5 of the 25 cases had such a condition; all 5 had a cerebral scar, 4 with retained bone fragments resulting from a penetrating wound. Two of the 5 had a small abscess within the scar. In all these 5 cases the intracerebral work was done via the bone defect, which was enlarged freely to give adequate exposure. The brain scar, with retained bone fragments, was excised *en bloc*, together with adherent dura. The dura was reconstituted with fascia lata and an acrylic 'graft' used to fill the bone defect.

In such operations there can be no preconceived idea of the size or shape of the eventual bone defect, so that acrylic or tantalum plates made to an impression of the skull defect via the scalp before operation cannot be used, and bone-grafting at the end of such operations is an unjustifiable added risk. For these cases the method described for skull defect closure is ideal.

BEHAVIOUR OF THE 'GRAFT'

There is little more fluid tissue reaction around acrylic plates than around rib grafts; whichever method is used, aspiration of fluid from beneath the scalp is usually necessary in the days following operation. In acrylic 'grafts' aspiration has never been necessary after the fifth day, and the fluid has always been sterile. In 2 cases the cytology of the fluid was followed.

	Red Cells	*Polymorphs*	*Lymphocytes*
Case A.—			
1st post-operative day	57,000	410	80
2nd " "	36,400	1,000	80
3rd " "	25,650	370	30
Case B.—			
1st post-operative day	250,000	White cells uncountable due to clot	
2nd " "	58,600	2,960	400
3rd " "	22,500	60	20

Electro-encephalographic records over the 'graft' are considerably flattened by the increased resistance of the acrylic plate. In 1 case in which the condition was definitely investigated, it was found that by increasing the amplification three times a record was produced identical with that seen before operation, showing that the physiological activity was probably unchanged.

RESULTS

Of the 25 cases of skull defect repaired with acrylic plates, 24 have made perfectly satisfactory progress and have at no time given rise to any anxiety. At the time of writing the longest follow-up on a case has been twenty-four months. This case was an excellent test because in this instance the 'graft' was in contact with the frontal sinus, separated from it only by a muscle-graft. It has never caused any trouble whatsoever.

One patient had a generalized epileptiform convulsion on the fifth post-operative day. He had not had a convulsion before operation. The original injury was seven months prior to operation for repair of the skull defect and caused marked cortical damage in the left fronto-parietal region. It is probable that the patient would have suffered this epileptiform convulsion in any case, but it was on the basis of a possible extradural collection of fluid beneath the 'graft' causing local pressure that it was decided to have one or more perforations in these plates to allow of escape to the surface of such accumulations.

The cosmetic results were extremely satisfactory in all cases. Although previously the patients all had a very conspicuous and disfiguring deformity of the head, after operation no abnormality in outline could be detected. It is because of the ease with which it enables one to reproduce any desired shape or outline that this method is particularly indicated for defects encroaching on the nasal and orbital regions.

One of the 25 cases was a failure and is reported here with observations on the causes. This patient originally received operative treatment in 1941 for a large subdural hæmatoma which became infected. As a result he was left with a large bone defect overlain with a thin T-shaped scar. The wound had been healed for two years when repair was undertaken. Tissue removed from the thickened dura at the time of operation contained small sterile fluid loculi, and on microscopy areas of infiltration by macrophages and foreign-body giant cells. Sixteen days after operation a *Staph. albus* infection developed beneath the scalp. This responded well to local penicillin instillation, but the T-scar broke down by necrosis at its junction point, exposing the surface of the acrylic plate. With infection controlled, it was interesting to observe granulation tissue beginning to grow across the plate in an attempt to fill the defect. Although this was never attained, it is evidence of lack of gross cytotoxic activity of acrylic resin. The removal of the 'graft' was, however, necessitated some two or three weeks later by further infection.

This failure shows many points of importance to be considered carefully when undertaking repair of skull defects in cases in which there has been sepsis at a previous date. It seems very probable that in this case there was a definite latent infection within the fibrous tissue of the dura which became activated by the operation. The inflammatory reaction caused increased tension of the scalp, with consequent pressure necrosis at the vulnerable T-junction of the old scar, which was very thin when 'grafting' of the skull was commenced. It is noteworthy that in this case there was no pre-operative

radiant heat or massage; as already indicated, such a precaution might well have revealed the likelihood of a possible flare-up of latent infection.

PRODUCTION OF THE ACRYLIC 'GRAFT'

The mechanical process of making the 'graft' can be carried out with the materials and apparatus found in most dental laboratories, with the exception that for any defect which is larger in area than a denture a specially made large metal flask will be required.

As soon as the impression is received in the laboratory a model of the bony defect is cast from it in artificial stone. A pattern of the proposed 'graft' is then built up in wax to fit this model and is carved and moulded to any desired shape and contour. A two-part mould is then prepared around this pattern, the two halves of this mould are separated, and the wax is removed. The mould is then packed with a doughy mixture of acrylic resin. This is condensed thoroughly, the mould is closed and heated in boiling water to polymerize and harden the acrylic. These are the main principles of the method; a brief pictorial description of the various steps in the laboratory technique is shown in *Figs.* 115–123. For further details standard books on dental prosthetics should be consulted.

A few improvements in technique should be mentioned here: Impression trays with a central 'window' cut out were found to minimize pressure on the dura and to prevent pulsation of the brain spoiling the impression. The use of stone models in preference to plaster is advised, and to avoid errors due to shrinking and warping when using large areas of wax it was found essential to process on a duplicate model. Finally, sterilization of the acrylic by boiling should be carried out with the 'graft' seated in the master model.

DISCUSSION

We first started using this method in July, 1943. At that time, although little had been written about it, it was known that acrylic resin had been used for repair of skull defects, both in this country and in U.S.A., and that the method was usually that of adapting a piece of manufactured acrylic sheet at the time of the operation by heating and bending to shape. The more reliable method we have described of direct impression-taking and the use of a mouldable acrylic dough subsequently hardened by heat treatment is an application of the accurate procedures of dental prosthetics. The authors have had no opportunity for very thorough investigation of the literature, but it seems probable that other workers have proceeded along the same lines in evolving a method for cranial repair. A similar technique was described by Shelden, Pudenz, Restarski, and Craig for making an acrylic calvarium to be used for direct observation of the brain in monkeys (1944).

Although this method of repairing skull defects has already given very satisfactory and useful results, we realize that there is still much room for further development, and from time to time, as a result of experience, certain changes and improvements are being made in the operative and laboratory techniques. Examples of this are the special preoperative care of scars overlying defects, and the drainage holes now made in the acrylic plates, the latter precaution being necessitated by the accuracy of fit between bone and plate. And now experiments have been made, with some success, in reducing the time of the laboratory technique and so enabling the operation to be completed in one stage.

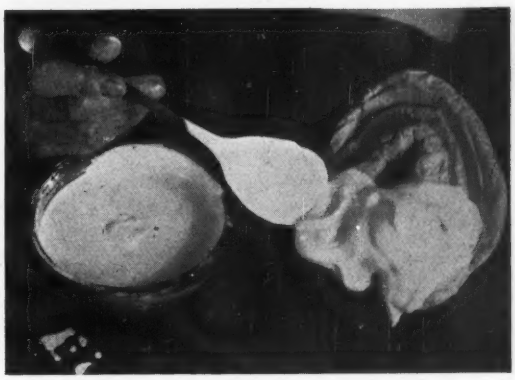


FIG. 115.—'Pouring' artificial stone into impression of bone defect. Bone defect in this case measured 10 × 11 cm.

FIG. 116.—Resulting master model after removal of hydrocolloid, showing reproduction of dural depression and undercuts beneath bony margin.

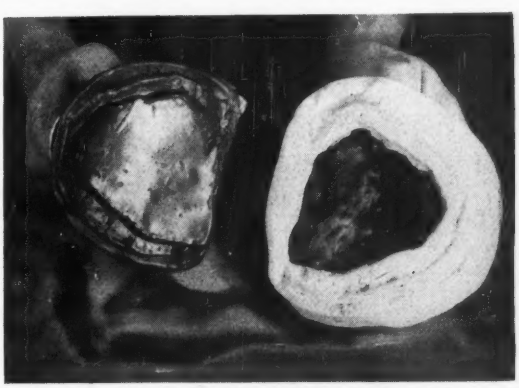


FIG. 117.—*Right*, Master model with depression and undercuts filled in with wax, the surface of which corresponds to the estimated plane of the inner surface of the lost bone. *Left*, Impression of corrected master model taken in dental composition to produce duplicate working model.

In the technique here described the special processing of the material has necessitated a two-stage operation. This is an inconvenience, although in practice we should not be carried out at the emergency operation and the acrylic plate prepared and 'filed' for future use.

FIG. 118.—Working model, cast in stone, having 'bone defect' restored in wax. The surface is built up and conformed to the curvature of the surrounding surface of the model, reproducing the correct shape of the lost bone. This wax pattern is then duplicated in acrylic resin by the method used in the processing of dentures.

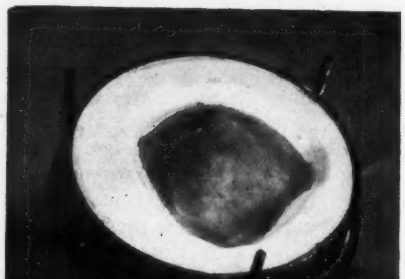


FIG. 119.—Working model and wax pattern invested in lower half of specially made copy of the standard denture flask. The surface of the surrounding plaster is oiled, the upper half of the flask filled with plaster-of-Paris, and while this is still soft the flask is closed.

FIG. 120.—After opening flask and removal of wax pattern the resulting space in the mould is being packed with the plastic mixture of the polymer and monomer.

FIG. 121.—Clamping the two halves of the mould together. Curing is completed by placing the flask in boiling water for an hour. After thorough cooling the acrylic is removed from the mould.

FIGS. 122, 123.—After trimming and polishing, completed 'graft' with master model.

have considered it to be outweighed by the excellent cosmetic results obtained.

In selected cases, where primary healing is anticipated, there is no reason why the first stage —that of step-cutting and impression-taking—

Unlike many other materials used for skull repair, acrylic resin is radiolucent (*see Fig.* 113), and we consider this to be a very important point in its favour. Many of the cases undergoing treatment will require periodic neurological examination, and

a material which owing to its opacity interferes with the taking of radiographs and encephalograms has serious disadvantages.

SUMMARY

1. A method is described of repairing cranial defects with acrylic resin.

2. The properties of this plastic are discussed. It is shown to be a tough, light-weight, inert, radiolucent, and adaptable material which seems particularly suitable for this purpose.

3. The necessity for closure of bony defects in the skull is considered.

4. The particular advantages of this method in operative defects is emphasized, as also is the ease with which large bone defects and defects encroaching on areas of irregular contour can be accurately restored.

5. Precautions regarding planning the scalp flap and the condition of the scalp are stressed, with special reference to pre-operative massage and radiant heat and to the excision of doubtful scars.

6. Operative details are given and the laboratory technique summarized.

Our thanks are due to the Officer Commanding this hospital for permission to publish this paper; to Brigadier Hugh Cairns for his encouragement and helpful criticism; to S/Sgt. L. G. Martin, for his valuable technical assistance; and to Pte. E. L. P. Tugwell, R.A.M.C., for preparing the photographs.

REFERENCES

BECK, D. J. K., RUSSELL, D. S., SMALL, J. M., and GRAHAM, M. P. (1945), *Brit. J. Surg.*, **33**, 83.

DRURY, G. B., CARESS, A., and CORIN, P. G. (1935), *Brit. Dent. J.*, **59**, 130.

OSBORNE, J. (1943), *Acrylic Resins in Dentistry*. Oxford Univ. Press.

SHELDEN, C. H., PUDENZ, R. H., RESTARSKI, J. S., and CRAIG, W. McK. (1944), *J. Neurosurg.*, **1**, 67.

THE SURGICAL TREATMENT OF TRAUMATIC ANEURYSMS

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THE surgical treatment of large aneurysms is fraught with difficulty and danger, and the successful management of such cases demands a high degree of technical skill together with a proper appreciation of the problems of this branch of surgery. The recording of these cases serves to indicate how problems have been met in individual instances, and such experiences are worthy of record as they are not so common as to be within the experience of most surgeons.

The surgical treatment of aneurysms dates from early times, and in the original operation of Antyllus the sac was laid freely open, all the blood and clot within the sac was turned out, and each end of the artery entering and leaving the aneurysm tied. "This may be one of the most formidable operations in surgery, and up to the days of Hunter many bold surgeons preferred to amputate the limb rather than expose the patient to the enormous primary and secondary risks, from hæmorrhage, diffuse cellulitis, and gangrene. Percival Pott spoke of the event of operation as 'always fatal' . . . and Hunter had not a single successful case" (A. Pearce Gould, 1895). It is not surprising that the surgeons of those days sought for less drastic methods of curing aneurysms. Diminution of the flow of blood through the aneurysm by ligature of the artery was a simple expedient, and the most effective site for such a ligature of the artery would be just above its point of entry into the aneurysmal sac. This operation was introduced by Anel in 1710, but it did not receive full acceptance owing mainly to the dangers of approach to the artery so close to the sac, dangers much increased when operations were performed in the days before Lister revolutionized surgery. Hunter (1785) ligatured the femoral artery and vein in Hunter's canal for an aneurysm of the popliteal artery, introducing the method of proximal ligature of the main artery well above the aneurysmal sac, and this was considered the method of choice up to the beginning of the present century. Ligature of the artery immediately distal to the aneurysm (Brasdor), and ligature of the artery at a point well beyond its point of exit from the aneurysm (Wardrop) were methods introduced to deal with those cases in which ligature of the artery proximal to the aneurysm was impracticable on account of its anatomical situation. Although cures were obtained by ligature of the artery, such cures were uncertain and failures were not uncommon. The reason for such failure was to be found in the excellent supply of blood still brought to the aneurysmal sac by collateral vessels. There was also the dread possibility of gangrene being produced as a result of ligature of the artery.

The introduction by Matas in 1888 of the operation of endo-aneurysmorrhaphy revived the older method of Antyllus, but operations were now performed with added safety owing to the introduction of Lister's principles of antisepsis and asepsis. Matas introduced three methods, the method of obliterative endo-aneurysmorrhaphy and the methods of restorative and reconstructive endo-aneurysmorrhaphy. The restorative method is the ideal operation, but is only applicable in saccular aneurysms. The reconstructive method which was introduced for fusiform aneurysms had been abandoned on account of the high incidence of post-operative thrombosis in the newly-constructed channel. The method of obliterative endo-aneurysmorrhaphy which is practically the old operation of Antyllus is the method of choice for such cases, and also for those cases of saccular aneurysm in which the arterial wall has been so extensively

destroyed as to preclude the performance of the method of restorative endo-aneurysmorrhaphy. The operation might, however, be attended by formidable and alarming hæmorrhage, even in cases where the circulation through the aneurysm has apparently been controlled by temporary clamping of the main artery above the aneurysm. The surgeon must be prepared to control the blood-loss by introducing his hand through a sea of blood into the aneurysmal sac in order to compress the main artery by digital pressure, from within the sac. Once this has been done and the blood-clots have been wiped away, cautious release of this pressure will reveal the orifices from which the blood will gush, and these orifices can then be closed by suture or ligature. The reinforcement of the suture or ligature line by pleating of the aneurysmal wall over it, as described by Matas, is not always practicable as the sac wall lacks the necessary texture and definition to permit of this, being merely made up of laminated blood-clot. In many of the cases described in this paper, this step was omitted without ill effect. In regard to obliterative endo-aneurysmorrhaphy, Gage (1943) writes : " The procedure is of the greatest simplicity. It consists simply of opening the aneurysmal sac and closure of the arterial openings of which there may be several, and then obliterating the sac. The suture material should be either cotton or silk, as absorbable sutures will give way with dire consequences." There is still place for the older operation of simple ligature of the main artery and also for the more drastic modern version of the operation of Antyllus, in which the entire sac is extirpated after ligature of every vessel entering and leaving the sac. Thus Pemberton and Black (1943), in a review of cases treated at the Mayo Clinic, record the method of ligature of the artery and excision of the sac for 4 cases of popliteal aneurysm with satisfactory results in all cases, and the same method for 2 cases of aneurysm of the superficial femoral artery, with gangrene and amputation as a result in 1 case. Gage (1943) considers that Anel's method of proximal ligature of the main artery still has a place in the treatment of aneurysms of the common carotid, subclavian, and external iliac or common femoral arteries. For an arteriovenous aneurysm of the left subclavian artery Touroff (1941) ligatured the first part of the subclavian artery via the transpleural route, using the same approach as he had been using for ligature of the patent ductus arteriosus.

The risk of gangrene of a limb following an operation in which the blood-flow through the main artery has been obliterated by the operative procedure should be minimized as far as possible. If the arteries distal to the aneurysm exhibit a normal pulsation, it is clear that most of the blood is still travelling through the main artery, and in the traumatic cases the aneurysm is likely to be saccular and suitable for treatment by the restorative endo-aneurysmorrhaphy method of Matas, which carries almost no risk of interference with the main circulation through the limb. If, on the other hand, there is no pulse in the arteries distal to the aneurysm, it is clear that the circulation is being mainly carried on by collateral vessels (Delbet's sign) and Matas advocates that the deficiency of the collateral circulation be estimated by the following method : The limb is blanched by elevating it and by the application of a firm elastic bandage. The main artery is now compressed above the aneurysm, the elastic bandage is removed, and the limb lowered. If the collateral circulation is efficient, there should be a blush in the blanched limb within three minutes. If the collateral circulation be deficient, it can be improved by removing the sympathetic vasomotor control to the limb either by the operation of sympathectomy (Pemberton and Black, 1943), or more temporarily by injection of the sympathetic field with novocain (Gage, 1943).

CASE REPORTS

Case 1.—**Traumatic aneurysm of the right axillary artery.**

HISTORY.—C. S. male, Sinhalese, aged 15 years, was admitted to the General Hospital on July 24, 1944, complaining of severe neuralgic pains radiating down the right upper limb, and a large pulsating swelling below the right shoulder.

Two months previously, while cutting wood in a jungle at Kekirawa, the patient had accidentally struck a metal object, which had exploded. He was wounded in the right shoulder, left knee, and left ankle by pieces of flying metal. The wound of the right shoulder bled profusely and he was admitted to the local hospital, where he was detained for fifteen days. A month after the accident he noted weakness of the right hand, the flexion movements of the thumb and index finger being particularly affected. There was also a lump in the armpit which steadily increased in size.

ON EXAMINATION.—The boy was seen to be suffering from severe pain. He sat in bed with his right elbow supported in his other hand, groaning in agony. There were two healed scars, each ½ in. long, on the front of the axilla over the pectoralis major muscle, and there was a large swelling bulging the anterior axillary wall from the clavicle down to the floor of the axilla (*Fig.* 124).

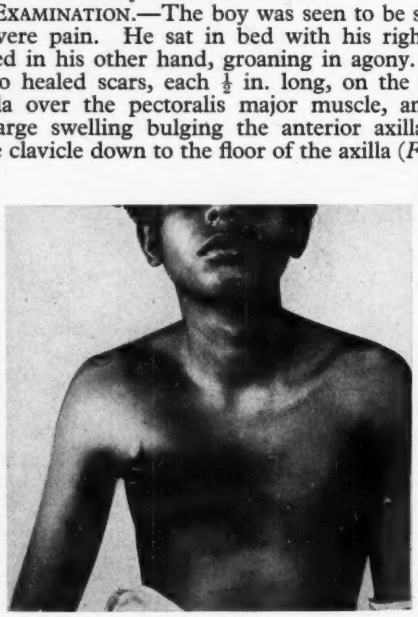

FIG. 124.—*Case* 1. Aneurysm of right axillary artery.

The entire floor of the axilla was bulged downwards by the swelling which extended from the anterior to the posterior walls. The swelling had an expansile impulse synchronous with the pulse, and there was a harsh systolic bruit heard on auscultation over it, conducted down the brachial artery for 2 in. The radial pulse on the right side was about one-third the volume on the left side. The patient was unwilling to move his elbow, but could be persuaded to fully extend and flex it. The movements of the wrist and fingers were unimpaired, except for the movements of flexion of the terminal phalanx of the thumb, and flexion of the index finger, which were weak

and could only be partially performed. A radiograph of the right shoulder showed a fragment of metal in the axilla.

AT OPERATION.—Under general anæsthesia on July 28, the third part of the right subclavian artery was exposed in the neck, and a tape was passed around the artery. The artery was temporarily clamped by tying the tape over a piece of rubber tube placed on the artery. The brachial artery was exposed just below the outlet of the axilla, and this artery was also temporarily clamped in the same manner. A curved incision was made on the front wall of the axilla. The sternal fibres of the pectoralis major muscle were divided at their insertion into the humerus, and the aneurysm, which lay immediately behind the muscle, was exposed. The walls of the aneurysm were made up of friable laminated blood-clot. The blood and clots were wiped away and it was noted that there was profuse hæmorrhage from the depths of the wound. This was controlled by pressing the fingers on to the axillary artery. An oval hole was seen in the artery which bled freely when the fingers compressing the artery were released. The hole admitted the tip of the finger. In spite of firm pressure, blood leaked through this hole, causing an appreciable blood-loss. The pulse-rate recorded 200 at this stage, and a blood transfusion of two pints was given. Attempts to close the hole with interrupted vaselined cotton thread sutures were not successful as the hole was too rigid to allow of this. The edges of the hole were apposed by clamping them with Spencer Wells artery forceps, and ligatures were tied below the forceps. There was no bleeding now, and on releasing the temporary ligatures on the subclavian and brachial arteries, the wound remained dry. It was now noted that there was good pulsation, of the same volume as the other side, in the right radial artery. The pectoralis major muscle was repaired by suturing its cut surfaces with catgut and the skin wounds were closed.

PROGRESS.—The patient made an uninterrupted recovery from the operation. After the skin sutures were removed, it was noted that he could not abduct

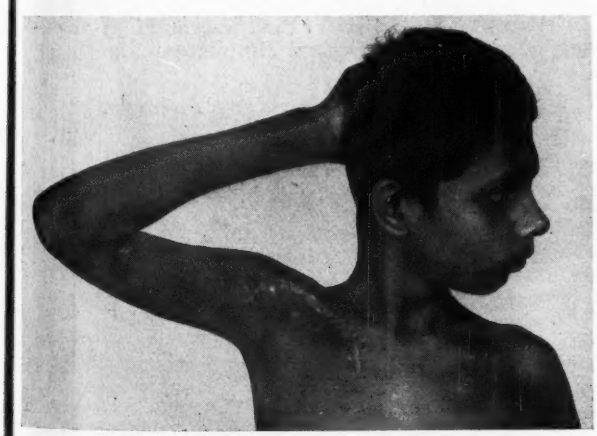

FIG. 125.—*Case* 1. After operation for right axillary aneurysm.

his shoulder, but this corrected itself in a few days (*Fig.* 125). At the time of leaving hospital on Aug. 18 there was still weakness of flexion of the index finger and thumb. The axilla has a normal contour, and the bruit over this area had disappeared. The pulse in both radial and ulnar arteries were of full volume and of the same force as of the opposite side. An X-ray picture taken before the patient left hospital showed that the piece of metal in the axilla was no longer present. It had probably been wiped out in the masses of blood-clot removed at operation.

Case 2.—**Traumatic saccular aneurysm of the left common carotid artery.**

HISTORY.—S., aged 25 years, male, Sinhalese, was referred to the General Hospital, Colombo, from the District Hospital, Deniyaya, on account of aphonia, paresis of the right hand, and some impairment of the mental function following a stab wound in the neck four months ago. There had been some surgical emphysema around the wound at the time of injury.

ON EXAMINATION.—The patient made unintelligible sounds on attempting to talk, and the history had to be taken from his mother, who stated that the patient had been stabbed in the neck four and a half months ago. There was a scar on the neck horizontally disposed at the level of the cricothyroid membrane, running from a point over the left sternomastoid muscle to just short of the middle line. There was no visible swelling in the neck and no distended veins. On palpation, a lump the size of a walnut was felt underlying the scar, and the lump exhibited an expansile pulsation synchronous with the pulse. A fine purring thrill was felt over the lump, and also over the left carotid and left subclavian arteries. On auscultation, a loud continuous murmur was heard like the sound of thunder, with an exacerbation at each systole of the heart. This murmur was heard most loudly over the left carotid and subclavian arteries, but it was also heard with lesser intensity over the manubrium sterni and the right carotid and subclavian arteries. The larynx and trachea were not displaced by the lump. The apex beat was palpable in the fifth space 1 in. outside the nipple line. The heart-sounds were normal. Blood-pressure 130/80. There was a notable weakness of grasp in the right hand. There was no weakness in the facial muscles or the muscles of the lower limb, nor was there any abnormality in the reflexes of the limbs, except for briskness of the knee-jerk on the right side. There was no loss of sensation. The left palpebral fissure was slightly narrower than the right, and the left pupil slightly smaller than the right. Both pupils reacted to light. There was no evidence of increased sweating on either side of the head or face. Indirect laryngoscopy showed the left vocal cord to be paralysed and lying in the adducted position.

It was apparent that the patient had developed an aneurysm of the left common carotid artery as a result of the stab wound. The absence of dilated veins in the head and neck negatived the possibility of an arterio-venous communication. The paralysis of the left vocal cord and the enophthalmos and small pupil on the left side pointed, respectively, to involvement of the left recurrent laryngeal nerve and the left sympathetic cord in the neck, either from the knife wound or from pressure of the aneurysm. The paresis of the right hand was possibly due to an embolus liberated from the aneurysm and lodging in the left side of the brain.

FIRST OPERATION (Nov. 3, 1939).—An incision was made along the anterior border of the left sternomastoid muscle, and the carotid vessels were exposed. There was an aneurysmal sac, the size of a walnut, on the outer side of the common carotid artery, displacing the internal jugular vein outwards (*Fig.* 126). The sac was carefully isolated, and it was found to have a narrow neck arising from the common carotid artery. The neck of the sac was cautiously ligatured with two silk ligatures. At this stage the sac was noted to be flaccid. The wound was closed.

PROGRESS.—The day after the operation, the patient was able to whisper intelligibly, and even produce a slight sound in his voice. The thrill over the carotid vessels persisted, as did the murmur, but it was of lower intensity than before. At the time of leaving hospital on Dec. 13, the patient could speak in a thin voice.

He was re-admitted on Jan. 16, 1940. The scar was keloidal. There was no lump in the neck. The fine thrill was still present, but the murmur was only heard over the arteries of the left side of the neck.

Blood-pressure, 110/70. Apex beat still 1 in. outside nipple line. No weakness in right hand. Voice almost normal, but indirect laryngoscopy showed that paralysis of the left vocal cord still persists. A second operation was advised as the persistence of the thrill and murmur was considered unsatisfactory.

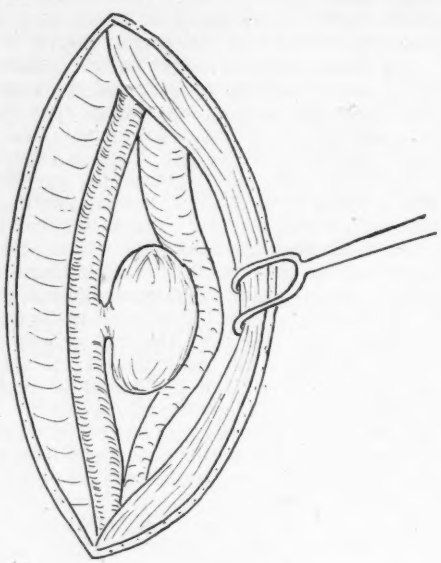

FIG. 126.—*Case* 2. View at operation of saccular aneurysm of left common carotid artery.

SECOND OPERATION.—This was performed on Jan. 19. The keloided scar was excised and the left common carotid artery exposed. There was now no trace of the aneurysm. The common carotid artery was, however, dilated to twice its normal diameter (*Fig.* 127). There was a good deal of scarring in the tracheo-œsophageal groove. The site of the aneurysm on the outer side of the left common carotid artery showed that the knife had pierced the outer wall of the left common carotid

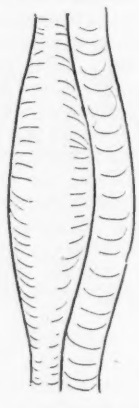

FIG. 127.—*Case* 2. View at subsequent operation, showing diffuse dilatation of left common carotid artery after excision of saccular aneurysm.

artery only, and it was therefore clear that the left recurrent laryngeal nerve could not have been severed by the knife. It was most probably involved by scarring on the tracheo-œsophageal groove. The persistence of the thrill and murmur was probably due to the diffuse dilatation of the carotid artery following the ligature of the aneurysmal sac.

PROGRESS.—The patient was re-admitted to the hospital on Sept. 17, 1944, for a follow-up examination. He was in good health and his voice was normal. The scar in the neck was no longer keloidal and was not noticeable. There was no thrill or murmur over the vessels of the neck (*Fig.* 128). The apex beat was still

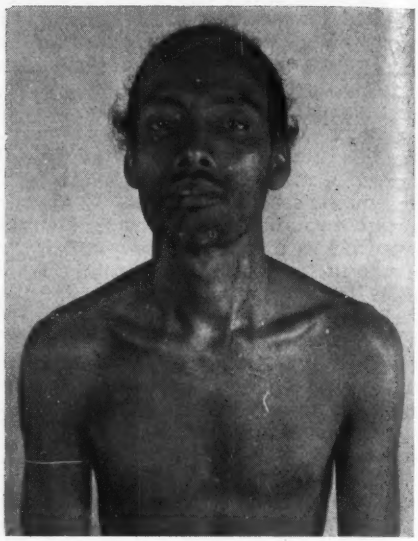

FIG. 128.—*Case* 2. The patient after operation. The operation scar and evidence of Horner's syndrome are seen in the photograph.

1 in. external to the nipple. There was still slight enophthalmos on the left side, and the left pupil was slightly smaller than the right. There was no weakness of the limbs, and the reflexes showed no abnormality. Indirect laryngoscopy showed that the left vocal cord was still paralysed.

Case 3.—**Traumatic saccular aneurysm of the right popliteal artery.**

HISTORY.—P. A., male, Sinhalese, aged 35 years of age, admitted to the General Hospital on Sept 2, 1937,

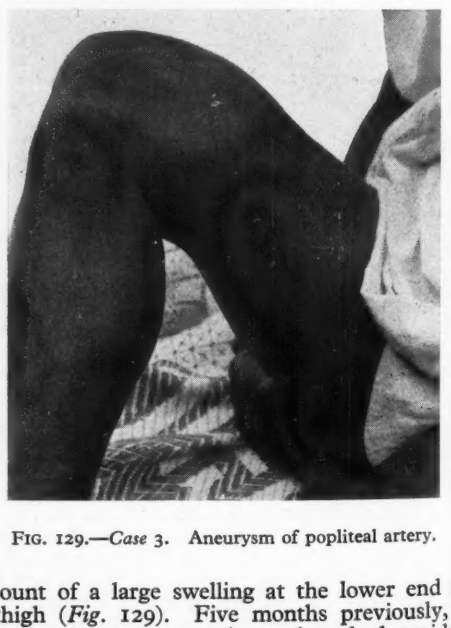

FIG. 129.—*Case* 3. Aneurysm of popliteal artery.

on account of a large swelling at the lower end of the right thigh (*Fig.* 129). Five months previously, while climbing a coco-nut tree, the patient had accidentally injured himself by sustaining a stab wound on the inner

side of the lower end of the right thigh. The wound had bled profusely at the time, but had healed uneventfully. A week after the injury the patient noted a swelling in the right thigh which gradually increased to its present size—that of a grape-fruit. There was now severe pain in the back of the knee, and he had to walk with a limp with the lower limb everted in order to avoid pain, as inversion of the limb increased the pain.

ON EXAMINATION.—A large spherical lump was seen on the inner side of the thigh extending from the upper half of the popliteal space up to the middle of the thigh. The swelling had an expansile pulsation synchronous with the pulse. There was a scar ½ in. long in the front of the thigh overlying the swelling. The sartorius, gracilis, semitendinosus, and semimembranosus muscles were behind the swelling and overlaid it in the popliteal space. On auscultation a systolic bruit was heard over the swelling. The pulsations of the dorsalis pedis and posterior tibial arteries were good. It was clear that the patient had developed a large traumatic aneurysm of the popliteal artery.

AT OPERATION.—Under general anæsthesia on Sept. 10 a tourniquet was applied round the upper end of the thigh, and an incision made upwards from the adductor tubercle along Hunter's canal.

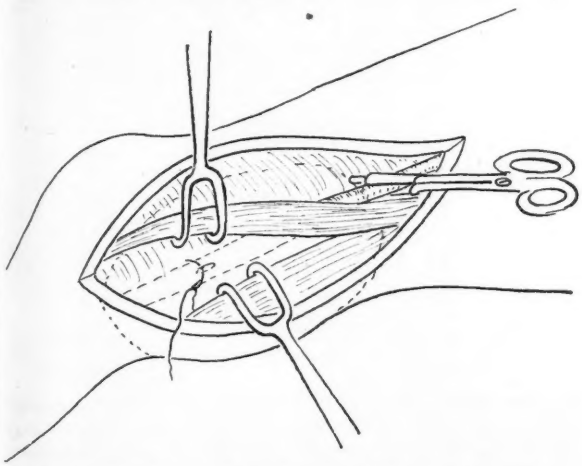

FIG. 130.—*Case* 3. Operation view of intrasaccular exposure of the hole in the popliteal artery. The outline of the sac is shown in dotted lines.

The femoral artery was exposed in Hunter's canal and temporarily clamped. The aneurysmal sac was seen to lie behind the adductor magnus muscle in the popliteal space (*Fig.* 130). An incision was made posteriorly over the popliteal space. The medial and lateral popliteal nerves were identified as they lay on the surface of the aneurysmal sac, and they were retracted to the lateral side. The popliteal vessels were identified at the lower pole of the aneurysm (*Fig.* 131) and were temporarily clamped. The first incision on the inner side of the thigh was reopened, and the aneurysmal sac exposed behind the adductor magnus muscle. The sac wall was white. The sac was opened and the laminated blood-clot and blood wiped away. The popliteal artery was seen on the further wall of the sac and it had a hole in its wall, which admitted the tip of the finger (*Fig.* 130). This hole was closed with interrupted sutures of fine vaselined silk, and the suture line was reinforced by pleating some of the adjacent wall of the aneurysm over it. The clamps on the femoral and popliteal vessels were released and the tourniquet removed. There was no bleeding. The wound was closed.

PROGRESS.—After operation the pulse was 104, and there was good pulsation in the dorsalis pedis and posterior tibial arteries of the same foot. On Sept. 27 there was a discharge of pus from the wound of the inner side of the thigh. This ceased after some days. At the time of his discharge from hospital on Oct. 27 the wounds had healed (*Fig.* 132). The patient was able to extend

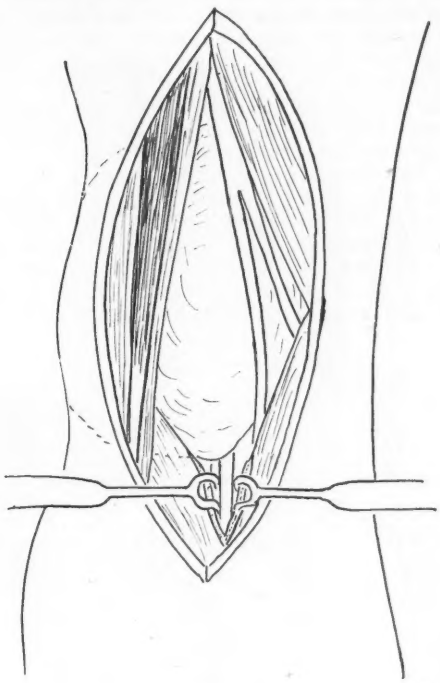

FIG. 131.—*Case* 3. Operation view of the aneurysm of the popliteal artery exposed by a posterior incision.

the knee fully, and could flex the knee from this position through a range a little greater than a right angle. He was able to walk well, the foot was warm, and there was no swelling of the foot. The swelling produced by the aneurysm was no longer present.

FIG. 132.—*Case* 3. After operation for popliteal aneurysm.

Case 4.—**Traumatic aneurysm of the third part of the axillary artery.**

HISTORY.—J. A. V. A., male aged 25 years, Sinhalese, was admitted to the General Hospital, Colombo, on Nov. 11, 1943, on account of a lump in the left armpit and severe neuralgic pains shooting down the left upper limb. Twenty-four days previously the patient had been

stabbed in the front of the left shoulder. The wound had bled profusely and he stated that he had lost consciousness. When he recovered he found himself in the local hospital, where his wound had been sutured. During the next five days the wound was apparently healing uneventfully, but on the sixth day he noted a lump in the left armpit, the size of a marble. He now had pain radiating down the outer side of the left arm. The lump steadily increased in size, and the pain began to radiate down the forearm also. The pain became more intense, and he now had paralysis of the fingers, wrist, and elbow. He decided to enter the General Hospital.

ON EXAMINATION.—The patient was seen to be suffering from severe pain and he sat with his left forearm supported in his other hand, groaning with pain. There was a healed scar on the anterior axillary fold, 1 in. in length. He had a wrist-drop on the left side. There was a lump in the left armpit extending from the anterior axillary fold to an inch short of the posterior axillary

FIG. 133.—*Case* 4. Aneurysm of the axillary artery.

fold. The lump was the size of a tennis ball, and on its summit there was a smaller projection, the size of a marble, which bulged the overlying skin and visibly pulsated (*Fig.* 133). On palpation the main lump had an expansile impulse synchronous with the pulse, and a systolic thrill which was also palpable in the proximal 2 in. of the brachial artery. On auscultation there was a harsh systolic murmur over the same area. Blood-pressure: Right arm, 100/75; Left arm, 95/65. The pulse at the left wrist was of poor volume. The left shoulder-joint movements were of normal range, but were difficult to elicit as the patient had poor control of the wrist and elbow. He was, however, able to move his shoulder through its full range. At the elbow active extension was lost. Flexion was normal to 90°, and from this point the arm fell without control into the fully flexed position. He was, however, able to flex the elbow through its full range against resistance. The movements of pronation and supination were clumsily executed. At the wrist-joint there was still full active flexion, but no extension, abduction, or adduction. He was able to flex the fingers strongly, but could not extend them fully. Abduction and adduction of the fingers were weak and were lost for the little finger and thumb. There was loss of sensation to pin-prick and cotton-wool touch over the left thumb and over the left little finger and ulnar edge of left ring finger together with the adjacent areas of the palm. There was loss of sensation to light touch only on the lateral aspect of the left forearm.

It was clear that the patient was suffering from a traumatic aneurysm of the third part of the left axillary artery, and that the aneurysm was causing harmful pressure on the nerve-trunks.

AT OPERATION.—Under general anæsthesia on Nov. 22 an incision was made above the left clavicle and the third part of the left subclavian artery exposed in the neck. A rubber tube was passed around the artery. An incision was made in the line of the brachial artery, and the commencement of the brachial artery was exposed. It was found to be reduced to a thin cord, which barely pulsated. The circulation in the subclavian artery was now controlled by clamping the rubber tube tautly round the artery. The incision over the brachial artery was prolonged over the axilla, and the lower edge of the pectoralis major was retracted upwards. The aneurysmal sac was exposed. The nerve-trunks were seen on the surface of the aneurysmal sac, the outer and inner heads of the median nerve being easily identified (*Fig.* 134). The aneurysmal sac was opened and the blood and clots were wiped away. The artery was found to be reduced to a shallow gutter on the posterior wall of the sac, and it was considered irreparable. The

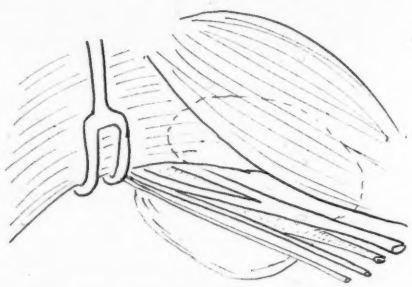

FIG. 134.—*Case* 4. Operation view of the aneurysm of the axillary artery.

axillary artery was tied from within the sac as it entered and left the sac. The clamps were released and, as there was no bleeding, the wound was closed. After operation the left hand was cold, but by 9 p.m. the same day it had become warm again. There was no pulse at the left wrist.

PROGRESS.—The patient made an uneventful recovery, but up to the time of his leaving hospital there was no improvement in the weakness of the left upper limb. He was discharged on Dec. 16, with the wound healed and without any recurrence of the aneurysm.

Case 5.—**Traumatic aneurysm of the left femoral artery.**

HISTORY.—H. F., aged 35, Maldivian Islander, was admitted on Nov. 28, 1938, complaining of a lump in the left thigh. He had been stabbed in the left thigh with a pair of scissors six months previously. The wound had bled profusely for some time, and the bleeding had then stopped. He had taken to his bed after the accident on account of severe pain in the thigh, and three days later he had noted the lump, which had got slowly larger and larger. The lump was at first more prominent on the inner and posterior aspects of the thigh, and it had slowly enlarged forwards. The wound on the thigh had healed in a month's time, but he had been confined to bed for five months because he was unable to straighten the left knee. In the last month it had been possible for him to straighten the left knee, and since then he had been up and about.

ON EXAMINATION.—There was a large lump on the inner side of the left thigh, the size of a husked coco-nut, occupying the lower half of the thigh (*Fig.* 135). The

skin over the swelling was stretched and shiny and many dilated veins were visible through it. The swelling was soft and pointing posteriorly through the skin, which was thinned. The skin was not attached to the swelling except posteriorly. The quadriceps muscle was on the antero-external side of the swelling and the hamstring muscles (semimembranosus and semitendinosus) were displaced to the inner side of the swelling. The swelling did not pulsate, except over the area where it was pointing through the skin, and no bruit was heard on auscultation over it. There was a healed scar 1 in. long over the front of the swelling at the site of the stab wound. The common and superficial femoral arteries showed good pulsation in Scarpa's triangle. No pulsation was detected in the popliteal artery, the dorsalis pedis artery, or the posterior tibial artery. Obliteration of the femoral pulse below the groin caused no appreciable diminution in the size of the lump. The foot and leg appeared normal. There was no œdema, the skin was warm, and there was good power in all the muscles. Palpation of the bones of the lower limbs showed no abnormality. Movements at the hip- and the knee-joints were of full range, and the

FIG. 135.—*Case* 5. Aneurysm of the femoral artery.

patient walked without a limp. A radiograph, taken on Nov. 29, showed appearances compatible with aneurysm. There was slight erosion of the shaft of the femur.

The history and the physical signs pointed to a diagnosis of traumatic aneurysm of the femoral artery in the lower half of the thigh.

AT OPERATION.—On Dec. 2, under spinal anæsthesia, a tourniquet was applied just below the groin and a long incision was made in the line of the femoral artery. The femoral artery was exposed at the apex of Scarpa's triangle and was temporarily clamped at this point. The incision was now deepened, and the aneurysm laid open. It was mainly filled with red blood-clot, which was scooped out by hand. On wiping the wound dry, the femoral artery was seen lying deeply on the postero-external wall of the aneurysm. The artery was traced downwards, and at the level of the old stab wound it was found that the wall had been lacerated widely over a length of 1½ in. The tourniquet was now released, but the clamp on the femoral artery was retained. The wound remained dry. An attempt was made to reconstruct the arterial lumen by suturing the wall of the aneurysm over a rubber tube inserted into the lumen above and below the damaged area. This was not satisfactory as the walls of the aneurysm were friable and widely separated. When these sutures had been applied and the clamp on the femoral artery was released, alarming hæmorrhage immediately occurred and the clamp on the artery was re-applied. It was now decided to ligature

FIG. 136.—*Case* 5. After operation for aneurysm of the femoral artery.

the femoral artery at the site of the clamp. When this had been done the wound remained dry and the long skin incision was closed.

The foot remained warm after the operation and the patient made an uninterrupted rcovery. He left hospital on Jan. 14, 1939, cured of his aneurysm and able to walk freely and without pain (*Fig.* 136).

Case 6.—**Traumatic aneurysm of the right femoral artery.***

HISTORY.—A. S., male, Sinhalese, was admitted on April 17, 1937, on account of a large swelling of the right thigh and on account of intense pain in this swelling.

FIG. 137.—*Case* 6. Aneurysm of the femoral artery.

Two months previously he had been stabbed in the right thigh. About ten days after the stab, when the wound had healed, he noticed that there was a swelling in the right thigh. The swelling had gradually got larger and had reached its present size about fifteen days ago. He had suffered a good deal from great pain on the inner side of the swelling, the pain shooting down to the knee.

On account of the pain he was obliged to keep his hip semiflexed.

* Previously reported in *J. Ceylon Br. Brit. med. Ass.*, 1937, July.

ON EXAMINATION.—A large swelling was seen in the front of the right thigh, extending from Poupart's ligament down to the middle of the thigh, where it ended in an elongated tail, running down Hunter's canal (*Fig.* 137). The scar of the stab, ¾ in. long, lay transversely

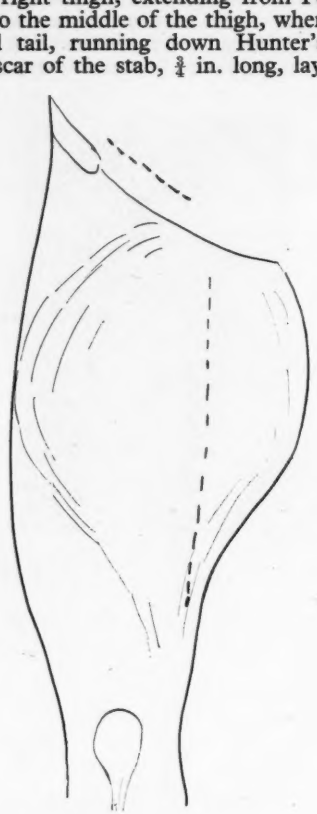

FIG. 138.—*Case* 6. A diagram showing the outlines of the aneurysmal sac and with the positions of the incisions made at operation shown by dotted lines.

on the front of the thigh at a point 2 in. below the anterior superior iliac spine. The skin over the swelling was stretched, tense, and shiny, and there were enlarged veins under the skin. The overlying skin pitted on pressure and the swelling was tender and soft. Over the inner aspect of the swelling, in the upper part of the thigh, was a well-marked palpable thrill. The swelling was noted to have a slight pulsation difficult to detect, but definitely present. A systolic bruit was heard over the swelling, but it was best marked over its upper inner aspect. The popliteal and the anterior and posterior tibial arteries were noted to have a normal pulsation. There was no œdema of the foot or leg, no paralysis of the muscles of the foot or leg, nor of the quadriceps or hamstring muscles, and no impairment of sensation on testing with cotton-wool.

The large swelling, with its palpable thrill and systolic bruit, pointed to the diagnosis of an aneurysm of the femoral artery. The stab wound and the history indicated clearly that the aneurysm was traumatic. A diagnosis of abscess was considered in view of the tense shiny skin over the swelling, the tenderness and warmth of the swelling, and the possibility of the infection having started from the stab wound, but the points already mentioned earlier made this unlikely.

AT OPERATION.—Under general anæsthesia on April 22. Stage 1: The right external iliac artery was exposed by Sir Astley Cooper's method, and a temporary clamp was placed on the artery above the origin of the deep epigastric artery. During the exposure of this vessel the purple walls of the aneurysm were visible, bulging upwards through the fat, deep to Poupart's ligament.

Stage 2: An incision was made over the lower end of Hunter's canal. The femoral artery was exposed in Hunter's canal and a temporary clamp placed on this vessel. During the exposure of this artery the subcutaneous tissues were noted to be œdematous.

Stage 3: Exposure and incision of the aneurysmal wall. The incision over Hunter's canal was prolonged upwards, the entire length of the thigh, in the line of the femoral vessels (*Fig.* 138). The aneurysmal sac was opened in the line of the skin incision. The walls of the sac consisted of laminated layers of organized blood-clot (*Fig.* 139). When this was scooped out there was an alarming hæmorrhage, filling the large cavity with blood in a few seconds. The fingers of the operator were plunged through this sea of blood on to the femoral artery at the level of the stab wound, and the artery was compressed against the adductor muscles of the thigh for several inches of its course. This manœuvre arrested the flow of blood. The blood was mopped out of the large cavity and the femoral artery was inspected. There was an oval hole, the size of the tip of a finger, lying vertically on the antero-external aspect of the superficial femoral artery. The edges of the hole were smooth and lined by endothelium. Five fine silk sutures, No. 00, well vaselined, threaded on a fine round-bodied needle, were inserted through the edges of the hole in the artery and tied securely. The hole was now closed. On releasing the digital pressure over the femoral artery no bleeding occurred in the wound. The clamps on the external iliac and femoral arteries were cleared. The wound remained dry. The extensive incisions were now closed without drainage.

PROGRESS.—The patient's pulse after the operation was 148, but it was of good volume. There was good pulsation in the dorsalis pedis artery, and the foot and

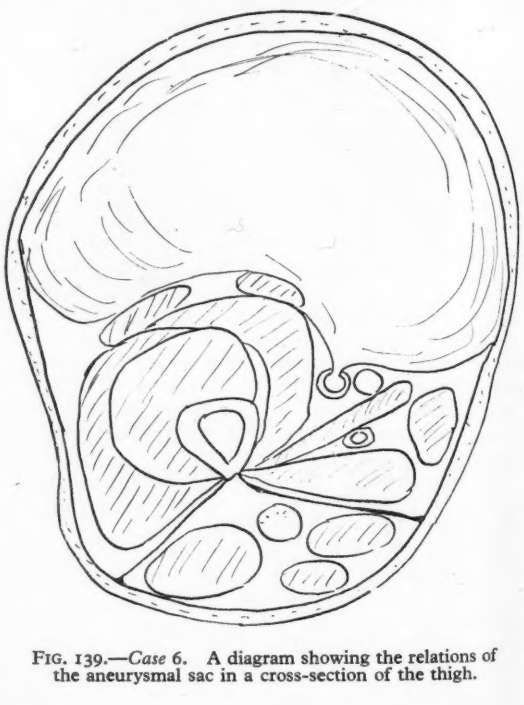

FIG. 139.—*Case* 6. A diagram showing the relations of the aneurysmal sac in a cross-section of the thigh.

leg were quite warm. The patient was nursed with his limb absolutely immobile between two sandbags. He developed slight œdema of the right foot for a few days, but the pulsation in the dorsalis pedis remained good and the foot remained warm. Ten days after operation the patient noticed on getting up in the norming that he was unable to move his left lower limb, which was painful.

The limb was swollen and the inguinal glands were enlarged and tender. There was an elongated zone of tenderness in the line of the long saphenous vein. At

this time the œdema of the right foot had subsided completely. The condition of the left limb was diagnosed as acute lymphangitis. The swelling of the left limb subsided in three days' time, and the temperature returned to normal. The wound in the right limb healed soundly, and the only legacy of the aneurysm was an indurated mass in Scarpa's triangle. The patient was not permitted to walk for three weeks. He left hospital twenty days after operation, with his wound healed and completely relieved of his symptoms (*Fig.* 140).

FIG. 140.—*Case* 6. After operation for aneurysm of the femoral artery.

Case 7.—**Aneurysm of the superficial femoral artery causing gangrene of the leg.**

HISTORY.—O. B., aged 75 years, male, Mohammedan Indian trader, was admitted to the General Hospital on Sept. 14, 1944, on account of gangrene of the right foot and leg. Seven months previously the patient had noted a lump in the right thigh which had gradually increased in size. He had sought advice previously, and had been told that it was necessary to amputate his limb on account of the lump, which was considered to be a tumour. Five days previously the foot had become green and dry and this had spread up the leg. No history of diabetes.

ON EXAMINATION.—The patient was seen to have dry gangrene of the right foot and leg, with a line of demarcation a hand's breadth below the knee. There was a large lump in the thigh bulging on its anterior and inner aspects, extending from four fingers'-breadth below the groin to a hand's-breadth above the knee-joint. The skin over the swelling had a normal texture. The swelling did not pulsate. There was some œdema of the tissues overlying the tumour. The common and superficial femoral arteries were felt passing from below Poupart's ligament up to the upper pole of the swelling. The walls of these arteries were calcified. The brachial and radial arteries were also extensively calcified, the calcified plaques being irregularly disposed rather than in annular rings. A small incision was made into the swelling of the thigh and blood spurted through the wound. The bleeding was arrested by means of a tight bandage placed over the incision. It was apparent that the gangrene of the foot and leg was the result of a large aneurysm of the superficial femoral artery, and the aneurysm was most probably the result of rupture of the rigid atheromatous vessel walls. An immediate operation was imperative in view of the incision that had been made into the aneurysm, and the gangrene of the foot and leg. Although the patient was old and feeble, the site of the aneurysm left no alternative but a disarticulation through the hip-joint. (*Fig.* 141.)

AT OPERATION.—Under general anæsthesia at 5 p.m., the right common femoral vessels were exposed and ligatured below Poupart's ligament. The walls of the artery were extensively calcified, and the artery was twice

FIG. 141.—*Case* 7. Photograph of the thigh after disarticulation through the hip-joint, showing the large aneurysmal sac.

the normal diameter. The limb was disarticulated through the hip-joint using an anterior racquet incision.

PROGRESS.—The old man stood the operation surprisingly well and was given half a pint of blood to counteract shock. His progress was satisfactory except for the fact that he was incontinent after operation, wetting the bed whenever the bladder became moderately full. On the fourth day he was refusing to take his food and appeared apathetic. There were now signs of consolidation of both bases of the lungs and the patient died on the ninth post-operative day.

This case is not one of a traumatic aneurysm, but it has been included on account of its special features.

Case 8.—**Traumatic aneurysm of radial artery.**

HISTORY.—G. H. A. P., male, Sinhalese, aged 22 years, was admitted to the General Hospital, Colombo, on account of a lump in the left forearm of six months' duration. He had injured his forearm seven months previously, while cutting down a branch of plantains. The wound had bled profusely. The wound had been firmly bandaged and it had healed in seven days' time. A month later a lump was noted at the site of the scar and this had slowly got larger. There had been numbness in the thumb and the index and middle fingers for some hours, every two or three days.

ON EXAMINATION.—There was a lump 2 in. in diameter in the front of the left forearm and in the line of the radial artery 1 in. above the palm (*Fig.* 142). There was a scar ½ in. long just below the lump. The lump had an expansile pulsation synchronous with the pulse. This pulsation could be arrested by pressure on the

radial artery above the lump. The lump could be moved from side to side, but not from above downwards. There was a systolic murmur over the lump. There was no loss of sensation to pin-prick or cotton-wool over the forearm or hand. It is clear that this patient had sustained a traumatic aneurysm of the radial artery.

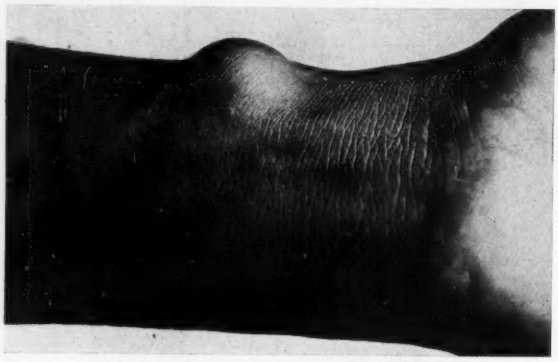

FIG. 142.—*Case* 8. Aneurysm of the radial artery.

AT OPERATION.—On Feb. 26, 1943, under general anæsthesia, a tourniquet was placed round the arm and a vertical incision made over the lump and the lump exposed. The radial artery entered above and emerged below it. The aneurysm was opened. It contained red blood-clot inside a thick sac. The arterial wall was reduced to a shallow groove in the floor of the sac. As the artery was considered irreparable, it was ligatured above and below the aneurysm and the sac excised. The wound was sutured.

The patient made an uneventful recovery from the operation and left hospital on March 3. There was no alteration in the warmth of the hand as a result of the ligature, and the only abnormality noted was the absence of the radial pulse.

SUMMARY

Eight cases of aneurysm are described. In 4 cases the aneurysm was traumatic and saccular, and the arteries distal to the aneurysm exhibited almost normal pulsation. In these cases Matas' operation of reconstructive endo-aneurysmorrhaphy proved thoroughly practicable, the patient being cured by the operation.

In 3 cases the aneurysm was traumatic and fusiform. The arteries distal to the aneurysm showed no pulsation. Matas' obliterative endo-aneurysmorrhaphy served, however, to cure these patients of their aneurysms. In 1 case, which unfortunately proved fatal, the aneurysm was due to the rupture of an arteriosclerotic calcified vessel. In this case the aneurysm had caused gangrene of the foot, which necessitated a disarticulation through the hip-joint.

REFERENCES

GAGE, M. (1943), *Amer. J. Surg.*, **59**, 210.
GOULD, A. PEARCE (1895), *A System of Surgery*, ed. F. TREVES, 496. London: Cassell & Co.
PEMBERTON, J. DE J., and BLACK, B. M. (1943), *Surg. Gynec. Obstet.*, **77**, 462.
TOUROFF, A. S. W. (1941), *Surgery*, **10**, 747.

SOME OBSERVATIONS ON CARCINOMA OF THE PROSTATE TREATED WITH ŒSTROGENS—AS DEMONSTRATED BY SERIAL BIOPSIES

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THE employment of œstrogen therapy for carcinoma of the prostate appears in many cases to offer opportunities of symptomatic relief hitherto unobtained by other methods. In some instances it is possible to detect a coincident regressive change in the size and consistency of the prostate gland, and also in those metastases which are accessible to palpation or radiography. However, in assessing such alterations in the prostate itself, or in lymph-gland and skin nodule metastases, much may depend on the judgement and veracity of the observer; while the comparative study of bone metastases may be confused through a failure to adopt a standardized radiographic technique. It has seemed to us that a method of treatment offering such promising clinical results would be established on a still firmer basis if visible regressive changes could be demonstrated in the microscopical structure of the organs concerned. Cytological changes in this direction have been recorded during the first two months of treatment (Schenken, Burns, and Kahle, 1942), but experience of the clinical course suggests that a more extended survey is desirable. We have, therefore, carried out repeated prostatic biopsies by the perurethral route in a small number of cases receiving œstrogens over periods ranging from six months to two-and-a-half years. The correlation of our microscopical findings with the clinical and biochemical records of the cases forms the basis of this paper.

It will be recognized that the cases from which our material has been obtained represent only a small proportion of those receiving œstrogens, since individual circumstances frequently render repeated interference neither opportune nor justifiable.

In this connexion it may be well to refer to the different types of the disease in so far as they affect the opportunities for the performance of serial biopsies. Disregarding the cellular structure of the neoplasm, it seems convenient to distinguish two forms, differentiated by the site of origin of the growth and the previous condition of the gland in which it occurs. In the more common form the growth tends to arise in atrophic tissue in the posterior lobe of an otherwise normal gland (Moore, 1935). Giving rise to few symptoms at the outset, it is seldom detected before extension has occurred, thus rendering the chances of successful radical extirpation remote. Indeed, according to Thompson

(1942), in 95 per cent of patients the disease has spread beyond the confines of the prostate gland by the time they come under observation. In contrast, the rarer form of the disease develops secondarily in a gland showing benign hypertrophic changes, and may often remain latent until discovered on routine microscopy of the enucleated prostate. This form is referred to by Riches (1944) as affecting older men and being less lethal in character, but it seems possible that the lowered pathogenicity may in some cases be accounted for by an assumption of complete eradication consequent on the enucleation. Its infrequency is apparent from figures given and quoted by McGavin (1938), and our own records show an incidence of 2 per cent in the microscopical study of one hundred enucleated 'adenomatous' glands.

In view of the foregoing it is clear that it is the first form of the disease which lends itself particularly to study, since it is both more common and, at the time of its detection, has usually extended to a portion of the gland readily approached by endoscopic methods. Our material has been obtained solely from cases falling into this category.

It may be well to reiterate that even in this class many cases are unsuitable for repeated examination, since their clinical condition may be either too bad or too good to warrant interference. A number of patients, particularly among the poorer classes, are still first seen when almost moribund from chronic retention and uræmia. In such cases we feel that any preference for perurethral methods of relieving the urinary obstruction should be subordinated to the performance of temporary suprapubic drainage by the Riches technique (1943). It has been our experience that not all of these advanced cases are able to derive full benefit from œstrogens on account of irretrievable renal damage (Fergusson, 1944), and in view of their rapid decline the chance of securing serial material is not presented. On the other hand, in earlier and more favourable cases showing a satisfactory clinical response to œstrogens, the clearance of urinary infection and diminution of residual urine may also obviate the need for prostatic resection.

Between these extremes patients are encountered in whom, after an initial resection and continued treatment with œstrogens, a milder degree of retention, frequency, or dysuria persists. It is in such cases, where, despite a general systemic improvement, some slight urinary symptoms remain, that we have considered further resection justifiable.

Having indicated some of the limitations imposed upon an investigation of this character we now turn to the method by which we have attempted to correlate the prostatic microscopy with the course of the disease. This has entailed a careful survey of the clinical, biochemical, and radiographic records of the appropriate cases, together with a consideration of the œstrogen dosage and any adjuvant methods of treatment. The manner in which the relevant data were recorded is briefly set forth below.

Clinical Findings.—A comprehensive note was made of the history and clinical state, with particular attention to the size and consistency of the prostate gland, the degree of urinary obstruction and infection, and the position and character of metastases. Similar observations were made on frequent occasions and the patient subsequently examined at monthly intervals in the Out-patient Department. All findings were recorded on a special chart designed to facilitate comparison (Fergusson).

Biochemical Tests.—Routine tests for renal function and urinary infection were performed at regular intervals in all cases and gave some indication of the degree of urinary obstruction.

Of more direct importance were the repeated estimations of the serum acid phosphatase upon which the dosage of œstrogen was largely based. These were carried out weekly at the commencement of treatment and later at longer intervals, and have seemed to us a valuable indication of the progress of the disease.

Radiographic Examination.—Anteroposterior views of the lumbar spine, pelvis, and upper ends of the femora were taken before commencing treatment and at two-monthly intervals thereafter. In some cases, where indicated, other regions such as the chest, skull, or humeri were included. An endeavour was made to maintain a constant technique with regard to position, exposure, and kilovoltage for each individual so as to simplify the comparison of metastatic deposits.

Occasional use was made of intravenous pyelography as an indication of the amount of residual urine where we did not wish to influence the course of the urinary symptoms by catheterization.

Treatment.—

Specific.—Of the 5 cases here described 4 were treated with stilbœstrol and 1 with dienœstrol. In general, we awaited the confirmation of the diagnosis by all available methods—palpation of the prostate, serum acid phosphatase estimation, radiographic evidence of metastases, and biopsy—before commencing treatment. However, in cases first observed with urinary retention œstrogen therapy was commenced on a provisional diagnosis during the stage of decompression, and biopsy performed within a few days. This seemed to us to give the maximum opportunity of restoring natural micturition and avoiding suprapubic drainage.

The dosages employed differed according to the clinical and biochemical findings, but usually initial doses of about 5 mg. of stilbœstrol or 2 mg. of dienœstrol were prescribed twice a day. The amount was reduced as soon as a satisfactory response was obtained, and maintenance doses of about 2 mg. of stilbœstrol or 1·0 to 1·5 mg. of dienœstrol twice daily continued.

Palliative.—Urinary infection and symptoms due to metastases received uniform palliative treatment on standard lines when necessary.

Operative.—Perurethral resection was carried out either before or shortly after the commencement of œstrogen therapy, and again on subsequent occasions during the continuation of treatment.

At the initial resection the aim was threefold—to remove obstructing tissue, to confirm the diagnosis by microscopy, and to obtain sufficient material to diminish any error in the microscopical comparison with tissue resected subsequently. The fragments were removed with the Gershom-Thompson (cold punch) instrument and the material to be examined taken from a similar site on each occasion, namely,

the posterior quadrant of the prostatic urethra immediately above the verumontanum. The danger of accidental selection of fragments, which by their anatomical structure might influence the distribution and extension of the growth, was thus somewhat diminished. From six to eight fragments measuring approximately 1 × 0·5 × 0·5 cm., and of total moist weight 1·0–1·2 g. were taken for examination. The possibility of a traumatic reaction resulting from the initial resection and affecting the microscopy of tissue obtained on a later occasion occurred to us, particularly if excessive diathermy cauterization was employed. For this reason special effort was made to avoid using diathermy for hæmostasis whenever possible after completing the resection, and reliance was placed mainly on the Foley's catheter and regular irrigation. Using similar restraint, a small number of serial biopsies in cases of simple prostatic hypertrophy was carried out and the traumatic reaction found to be negligible.

Proceeding on these lines a degree of uniformity was achieved which we hoped might be reflected in the microscopical findings. The material obtained consisted of prostatic tissue fragments taken on two or more occasions from five patients belonging to the clinical group to which we have referred. In all the patients our records showed general improvement from the clinical and biochemical standpoints following the employment of œstrogens.

MORBID HISTOLOGY

A preliminary study of sections of the prostatic tissue obtained at the initial and subsequent resections showed both quantitative and qualitative changes in the neoplastic areas. In addition to an apparent reduction in the number of tumour units in the later sections certain cellular changes were noticeable, among which a diminution in the size of the nuclei was prominent. These findings suggested that a detailed comparison could best be made in two directions; first, by a quantitative estimate of the number of tumour units in fields of standard size, and secondly, by a descriptive record of the cellular changes, substantiated by measurements of the nuclear diameters. It was clear, however, that any quantitative comparison of the tumour units would be influenced by vagaries of anatomical structure and by the extent and cellular differentiation of the growth. The former difficulties could be minimized by the examination of extensive areas of tissue, and for this reason we made a large number of serial sections of all representative fragments. The impracticability of counting tumour units in the one case of undifferentiated carcinoma, however, proved insuperable and forced us to adopt a descriptive comparison in this instance.

For comparative purposes the number of tumour units in microscopical fields amounting to 10 sq. mm. was counted by impartial observers, and an average taken corresponding to the number of units per sq. mm. Apart from a consistent decrease in the later sections, the majority of units also showed considerable diminution in size. The effect produced can perhaps be best appreciated by reference to *Figs.* 143–147, which show representative fields taken from sections of the initial and subsequent biopsy material in the five cases. The general trend illustrated appears to be a regressive change from a more cellular type of growth to a scirrhous form.

The numerical estimates of the tumour units, correlated with the interval between the resections and the amount of œstrogen received, are given in *Table I.*

Table I.

Case	Number of Resections	Interval Between Resections	Amount of Œstrogen Received	Tumour Units Per Square Millimetre
1	1	Initial	Stilbœstrol	66
	2	10 days	100 mg.	—
	3	17 months	4380 mg.	23
2	1	Initial	Stilbœstrol	Uncountable (undifferentiated carcinoma)
	2	5 months	1980 mg.	*See Fig.* 144
	3	16 months	4128 mg.	
3	1	Initial	Stilbœstrol	50·1
	2	10 months	1792 mg.	8·1
4	1	Initial	Stilbœstrol	78·9
	2	30 months	3548 mg.	28·0
5	2	Initial	Dienœstrol	150
	1	6 months	500 mg.	30

In addition to a numerical comparison of the units of growth we hoped to be able to confirm and supplement the findings of Schenken, Burns, and Kahle (1942) with regard to qualitative microscopical changes. For this purpose fresh sections were prepared from the biopsy tissues and stained simultaneously. A comparison again revealed well-marked changes in the later sections, showing a tendency towards diminution in size of the cell nuclei, with concentration of chromatin and pyknosis. In the sections made from the initial biopsy material, the majority of tumour cells had large vesicular nuclei, although a number of pyknotic nuclei were also present. In sections made from later material pyknotic nuclei were found almost exclusively in four of the cases, and in many instances these appeared to be free, the retaining cellular body having disintegrated. In two of the cases progressive vacuolation of the cells was also observed.

To supplement the description of the cytological changes we recorded measurements of the nuclear diameters in all the cases. This procedure, again carried out by impartial observers, was tedious and involved the measurement of between 1000 and 1500 nuclei in each case examined. A comparison of the average diameters of the nuclei in the cases examined confirmed our original visual impression, and the results are given in *Table II.* This shows a notable decrease in size in three of the cases, while in the remaining two (*Cases* 3 and 4) the change is slight.

In order to emphasize the general nature of the diminution in nuclear size in these cases we have reproduced our results in graphic form (*Figs.* 148–152).

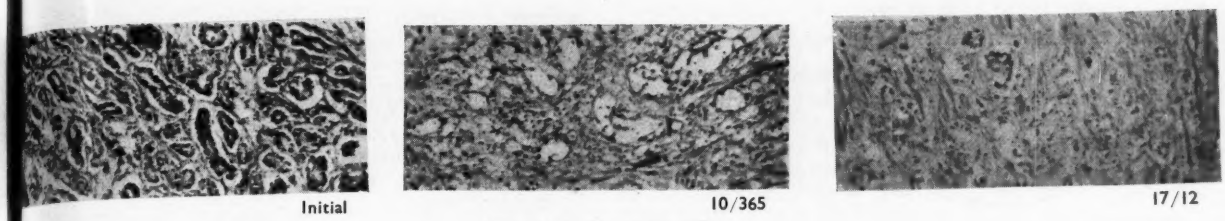

Fig. 143.—*Case* 1 (× 16).

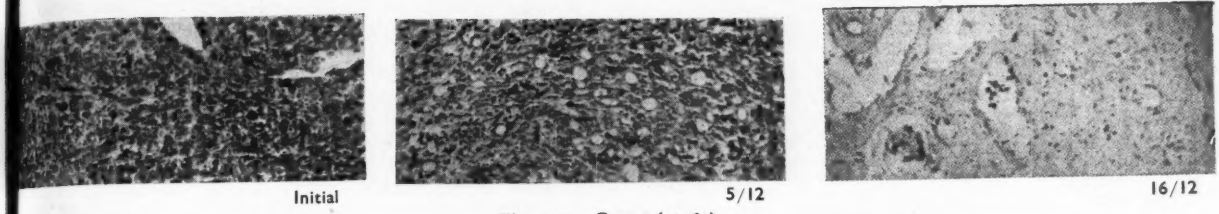

Fig. 144.—*Case* 2 (× 60).

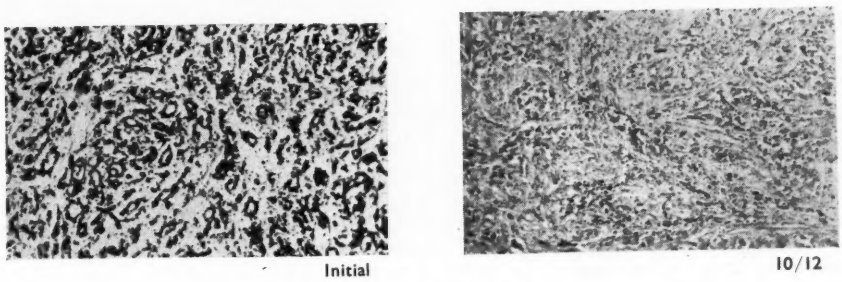

Fig. 145.—*Case* 3 (× 60).

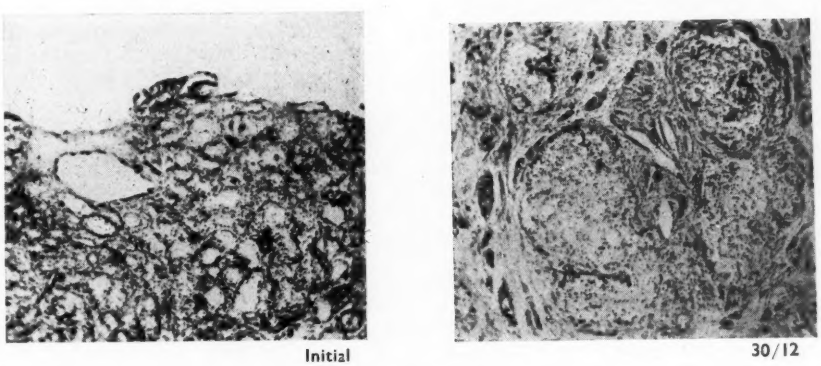

Fig. 146.—*Case* 4 (× 44).

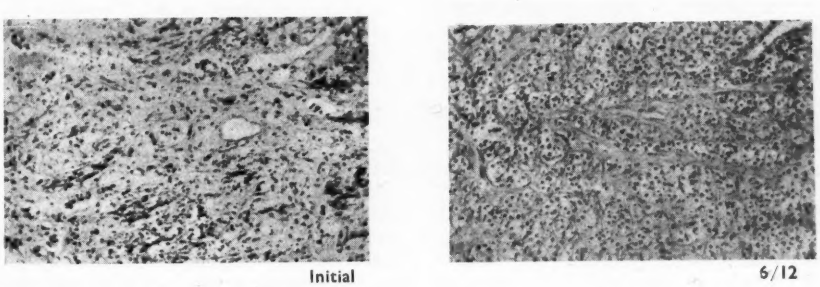

Fig. 147.—*Case* 5 (× 60).

FIGS. 143–147.—Microphotographs of representative sections taken from serial biopsy material in the five cases, showing diminution in number and size of the tumour units. The intervals between the biopsies are indicated beneath each section.

Table II.

Case	Interval Between Resections	Amount of Œstrogen Received	Average Diameter of Nuclei in Microns
1	Initial 10 days 17 months	Stilbœstrol 100 mg. 4380 mg.	7·75 4·82 4·65
2	Initial 5 months 16 months	Stilbœstrol 1980 mg. 4128 mg.	9·75 — 5·95
3	Initial 10 months	Stilbœstrol 1792 mg.	7·32 6·11
4	Initial 30 months	Stilbœstrol 3548 mg.	7·2 6·9
5	Initial 6 months	Dienœstrol 500 mg.	6·28 4·23

In brief, the histological findings were that the later sections showed a notable reduction in tumour units in all cases, with a coincident decrease in size in three. Retrograde cytological changes were apparent in all cases, and in three instances there was a statistically significant diminution in the average nuclear diameter.

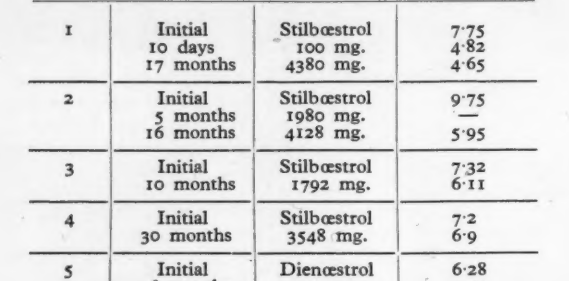

Fig. 148.—*Case* 1.

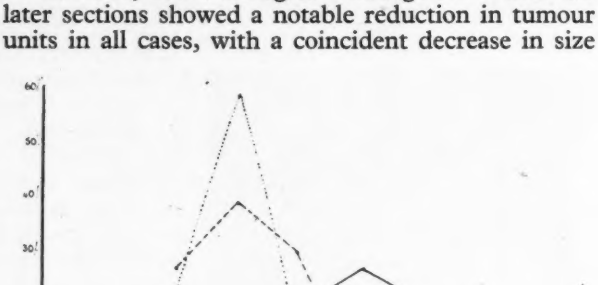

Fig. 149.—*Case* 2.

CASE REPORTS

Brief histories of the cases are appended with the inclusion of the relevant biochemical and radiographic records.

Case 1.—

History.—A patient aged 75 complained of increasing difficulty of micturition for one year culminating in inability to pass water. Frequency (diurnal 1-hourly, nocturnal 1½-hourly) had been troublesome and there had been slight scalding on urination. Pains in the outer and posterior portions of the thighs had recently become aggravated.

He was found to have a distended bladder, and rectal examination revealed a hard, nodular prostate with fixation to the surrounding structures. A considerable degree of anæmia was present and it was evident that he had lost weight.

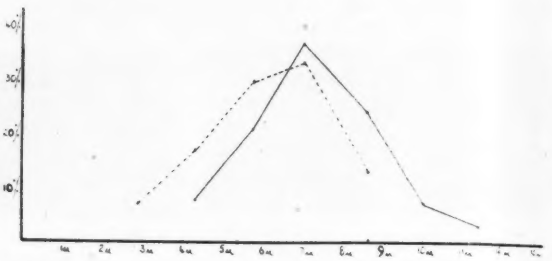

Fig. 150.—*Case* 3.

Fig. 151.—*Case* 4.

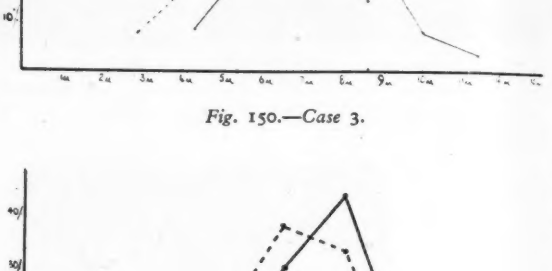

Fig. 152.—*Case* 5.

Figs. 148–152.—Graphic records showing the change in the nuclear diameters. The percentage of nuclei of certain size is plotted against the nuclear diameters. The continuous line represents the initial state, and the broken lines the later findings. A shift from right to left indicates the reduction in average nuclear diameter.

Biochemical examination showed a blood-urea content of 89 mg. per 100 c.c., and a serum acid phosphatase value of 3·5 units per 100 c.c.

Radiographs indicated the presence of metastases in the pelvis and lumbar spine, and also in the neck of the left femur.

Treatment.—The retention was relieved by slow decompression by indwelling catheter, the urine containing a small amount of pus and growing *B. coli* on culture. At the same time treatment with stilbœstrol (5 mg. twice a day) was instituted. Following withdrawal of the catheter he was still only able to pass urine with difficulty. Perurethral resection of prostatic tissue was first carried out four days after the commencement of œstrogen therapy and again ten days later.

PROGRESS.—His subsequent progress was satisfactory, the residual urine diminishing to less than an ounce and his frequency abating to twice nightly and two-hourly during the day. He made no further complaint of pain, and increased his weight by over a stone in six months. The blood-urea content fell to 33 mg. per 100 c.c., and the average serum acid phosphatase value on subsequent estimation was 1·5 units per c.c. The hæmoglobin rose from 59 per cent to 95 per cent.

Œstrogen dosage varied between 6 mg. and 15 mg. of stilbœstrol daily, until after sixteen months it was thought desirable to reduce it to 4 mg. a day on account of increasing headaches and dizziness. Following the reduction he experienced slight difficulty of micturition, and the third perurethral resection was performed a month later. The serum acid phosphatase value at this time was 1·4 units per c.c. He has since continued in good health on a daily dose of 4 mg. of stilbœstrol, and has now received treatment for over two years. The prostate, although smaller and softer, remains recognizably 'malignant' on palpation. Radiographic records show little change in the character and distribution of the bony metastases.

Side Effects.—The sensation of dizziness, which has been noted in other cases receiving œstrogens, appeared to be closely related to the taking of stilbœstrol. The patient volunteered the information that he had found relief on omitting to take the tablets for short periods, and remained almost free from trouble after the reduction in dosage. Some rise of blood-pressure took place prior to the onset of the disturbance, and this has since continued at a high level.

Slight tenderness of the breasts occurred after six months' treatment, but has now disappeared. The testes have become shrunken and sexual activity much reduced.

Case 2.—

HISTORY.—A patient aged 72 was admitted to hospital suffering from retention of urine. He had suffered from extreme frequency of micturition for some months, having to rise from bed as often as twelve times during the night. During the two months prior to his admission he had been afflicted with agonizing pains in the outer side of the thighs. He stated that he had recently lost weight.

On examination he was found to have a distended bladder and his prostate felt extremely hard and nodular, with extension of the induration into the surrounding tissues on the left side.

Biochemical examination showed a blood-urea content of 42 mg. per 100 c.c., and a serum acid phosphatase value of 9·5 units per c.c.

Radiographs indicated the presence of scattered secondary deposits in the pelvis, and also in the ribs and clavicles.

TREATMENT.—The retention was relieved by slow decompression by indwelling catheter, the urine containing a small amount of pus and growing *B. coli* on culture.

Treatment with stilbœstrol (5 mg. twice a day) was commenced at the same time. On withdrawal of the catheter four days later he remained unable to pass urine, and perurethral resection was carried out.

PROGRESS.—One month later his general condition had much improved, and while able to micturate with ease, he was able to forego this satisfaction for periods of up to three hours at a time. His residual urine declined to between ½ oz. and 3 oz., and became sterile on culture. The pains in his thighs diminished in intensity and he began to put on weight.

The serum acid phosphatase value fell to 2·1 units per c.c., and subsequently remained on the average at 2·4 units.

Five months after the commencement of treatment he began to experience further difficulty in passing urine, and the second perurethral resection was performed. Following this he remained in good health on an average dose of 6 mg. of stilbœstrol daily, and put on 8 lb. in weight.

The third perurethral resection was carried out sixteen months after the commencement of treatment on account of an increase in the residual urine.

At the present time, after two years' treatment with stilbœstrol, he remains free from pain and complains of no urinary disturbance apart from having to micturate three times during the night.

Palpation of the prostate shows this to have become very small, but the degree of induration is still suggestive of carcinoma. Radiographic records show no change in the character of the metastases.

Side Effects.—Considerable mammary enlargement and tenderness took place after the first month of treatment, and more recently a very marked dark-brown pigmentation has occurred over a circular area, about 2½ in. in diameter, surrounding the nipples.

The testes have become very small and sexual activity is absent.

Case 3.—

HISTORY.—A patient aged 61 attended hospital on account of progressive difficulty in passing water for nearly a year and recent hæmaturia. Occasional pain in the thighs had been experienced. His general condition was comparatively good, but on rectal examination his prostate was found to be indurated and nodular to an extent suggesting malignancy.

Biochemical examination showed a blood-urea content of 47 mg. per 100 c.c., and a serum acid phosphatase value of 15·5 units per c.c.

Radiographs indicated the presence of both osteoplastic and osteolytic deposits in the pelvis.

TREATMENT.—At cystoscopy he was found to have 10 oz. of residual urine, which contained a little pus and grew the *B. coli* on culture. Perurethral resection of the obstructing prostatic tissue was carried out, and microscopy of the fragments removed confirmed the diagnosis of carcinoma.

Treatment with stilbœstrol (3 mg. daily) was instituted.

PROGRESS.—Following this he was able to comment that he was passing water more easily than for years, and his residual urine fell to 2 oz. and became sterile. No further pain was experienced in the thighs. The blood-urea content remained between 40 mg. and 50 mg. per 100 c.c., but the serum acid phosphatase value fell to 1·2 units per c.c., and remained at this average level on subsequent estimation.

Œstrogen dosage varied between 0·5 mg. and 4 mg. of stilbœstrol daily.

His weight remained constant, and apart from occasional dizziness he remained free from symptoms until ten months later, when the second perurethral resection was carried out on account of the return of slight dysuria and an increase in the residual urine. Since this time his progress has been maintained and at present, after fifteen months of œstrogen therapy, his general condition shows marked improvement. The prostate is now almost impalpable, and though remaining firm would not arouse suspicion as to its malignant nature.

Radiographs show no alteration in the character and distribution of the bony metastases.

Side Effects.—Occasional attacks of dizziness were esperienced for some months during treatment and a slight rise in blood-pressure took place.

The breasts, which showed considerable enlargement and tenderness, now show some regression.

After three months' treatment he noticed a smaller ejaculate and shrinkage of the testes. Sexual activity disappeared completely. Indeed, after an alleged incident near his place of employment he was vigorously able to defend himself against imputations of peculiar behaviour.

Case 4.—

HISTORY.—A patient aged 70 was admitted to hospital with retention of urine following increasing difficulty in passing water for nearly a year. Frequency of micturition had been troublesome, and he had experienced pain in the lumbar region and inner part of the thighs which almost prevented him from walking.

His bladder was distended, and the prostate, although relatively small, was hard and nodular. A considerable degree of anæmia was present and œdema of the ankles was marked.

Biochemical examination showed a blood-urea content of 86 mg. per 100 c.c., and a serum acid phosphatase value of 30·0 units per c.c.

Radiographs showed the presence of metastases in the pelvis.

TREATMENT.—His retention was relieved by slow decompression by an indwelling catheter, the urine containing a small amount of pus and growing *B. coli* on culture.

Following withdrawal of the catheter he was able to pass urine fairly well, but his residual urine still amounted to nearly half a pint. Perurethral resection of the obstructing tissue was carried out, and thereafter he made good progress.

PROGRESS.—Owing to unfamiliarity with the effect of œstrogens at this time he received only sporadic courses of treatment with stilbœstrol during the next few months, and was later readmitted with a further attack of urinary retention which was relieved by catheterization.

Thereafter he was maintained on doses varying between 4 mg. and 15 mg. of stilbœstrol daily, controlled by the serum acid phosphatase value. This value fell to an average of 1·2 units per c.c. on subsequent estimations, and the blood-urea content to 36 mg. per 100 c.c.

His later progress was satisfactory and he began to put on weight. Although he still complained of occasional pain in the thighs, this no longer interfered with his walking.

A second perurethral resection was carried out thirty months after the commencement of treatment on account of an increased difficulty in initiating micturition. He has since remained well and has now been under treatment for three years. The prostate is very small and hardly palpable, though still of firm consistency.

Radiographs show slightly increased sclerosis in some of the bony metastases, with corresponding hardening of outline.

Side Effects.—Tender enlargement of the breasts was noted after a month's treatment. Shrinkage of the testes and pigmentation of the perineal raphe also occurred.

Case 5.—

HISTORY.—A patient aged 60 complained of general asthenia and pain in the right hip for several months. In addition, he had noticed increasing frequency and scalding dysuria, and marked loss of weight.

His general condition was poor and he was profoundly anæmic. The prostate was hard and nodular, with fixation to the surrounding structures.

Biochemical examination showed a blood-urea content of 48 mg. per 100 c.c., a serum acid phosphatase value of 7·5 units per c.c., and a hæmoglobin percentage of 44.

Radiographs showed the presence of metastases in the pelvis, lumbar spine, and necks of both femora.

TREATMENT.—A perurethral biopsy of the prostate was performed to confirm the diagnosis and œstrogen therapy commenced, using dienœstrol in doses of 3 mg. a day.

PROGRESS.—Rapid improvement occurred, accompanied by loss of pain and relief of the urinary symptoms. His hæmoglobin rose from 44 per cent to 90 per cent, and he put on 2 st. in weight in six months.

The blood-urea content fell to 35 mg. per 100 c.c., and the serum acid phosphatase value declined to an average of 2·8 units per c.c.

The dosage of dienœstrol varied between 3 mg. and 5 mg. daily.

A modified perurethral resection was carried out after six months on account of some persistence of nocturnal frequency, but the amount of residual urine was less than 2 oz.

Table III.

CASE	INTERVAL BETWEEN RESECTIONS	TUMOUR UNITS PER SQ. MM.	AVERAGE DIAMETER OF NUCLEI IN MICRONS	AMOUNT OF ŒSTROGEN RECEIVED	CLINICAL COURSE	SERUM ACID PHOSPHATASE	RADIOGRAPHIC FINDINGS
1	Initial 10 days 17 months	66 — 23	7·75 4·82 4·65	Stilbœstrol 100 mg. 4380 mg.	General improvement; loss of pain; gain (1 st.) in weight; hæmoglobin 59–95 per cent; prostate became smaller and softer	Initial 3·5 units; subsequent average 1·5 units	No appreciable change
2	Initial 5 months 16 months	Uncountable (undifferentiated) carcinoma) — —	9·75 — 5·95	Stilbœstrol 1980 mg. 4128 mg.	General improvement; loss of pain; gain (8 lb.) in weight; prostate became smaller but still firm	Initial 9·5 units; subsequent average 2·4 units	No appreciable change
3	Initial 10 months	50·1 8·1	7·32 6·11	Stilbœstrol 1792 mg.	General improvement; loss of pain; weight constant; prostate became very small but firm	Initial 15·5 units; subsequent average 1·2 units	No appreciable change
4	Initial 30 months	78·9 28·0	7·2 6·9	Stilbœstrol 3548 mg.	General improvement; diminution of pain; increase of weight; prostate became very small but firm	Initial 30·0 units; subsequent average 1·2 units	Some increased sclerosis and hardening of outline of deposits in later films
5	Initial 6 months	150 30	6·28 4·23	Dienœstrol 500 mg.	General improvement; loss of pain; gain (2 st.) in weight; hæmoglobin 44–90 per cent; prostate became smaller and softer	Initial 7·5 units; subsequent average 2·8 units	Increased sclerosis of deposits in later films

His recent progress has been satisfactory, and after one year's treatment he remains free from symptoms. The prostate has become very small and though softer is still recognizably malignant.

Radiographs show increased sclerosis in the bony metastases.

Side Effects.—Occasional dizziness was complained of at the onset of treatment, but this may have been caused by the anæmia. Very slight tenderness of the nipples was noted during treatment, but no palpable enlargement of the breasts.

Sexual activity has declined and the testes have diminished to half their normal size.

Table III gives a comprehensive review of the histological findings and the clinical, biochemical, and radiographic records of the five cases.

Comment on the Cases.—All the above cases have been subjected to perurethral resection of obstructing prostatic tissue in addition to receiving œstrogen therapy. The difficulty in ascribing their improvement to either or both methods of treatment is immediately evident. It is clear that the operative measures must have a direct, though possibly temporary, effect on the urological condition, and, to avoid prejudice, we have omitted any record of the amelioration of urinary symptoms in the above table. As to how far the general improvement may be a reflection of relieved urinary obstruction is less certain, and we have therefore tabulated this as a fairer index of the œstrogenic response.

DISCUSSION

The treatment of prostatic carcinoma with œstrogens has been largely developed from the observations of Huggins and his associates (1941), showing that normally active prostatic epithelium could be made to atrophy by neutralizing the androgenic hormones. The investigations which we have described lead us to believe that the unrestrained epithelial activity of prostatic carcinoma may respond in a similar manner. Our cases are too few, however, to enable us to do more than suggest that regressive histological changes are a fairly constant accompaniment of œstrogen therapy. No conclusions can be drawn, as yet, as to the possibility of complete destruction of a developed carcinoma by means of œstrogens. It will be observed that in none of the cases has a complete disappearance of carcinomatous tissue been noted. This may be due to our method of selection, and it is conceivable that some patients who become dispossessed of all clinical evidence of the disease may attain such a favourable result. From our experience of cases outside the present series, however, we know of no instance in which such a clinical 'cure' has been accompanied by radiographic evidence of the complete dissolution of bony metastases.

We also recognize that our histological studies may not be wholly representative in that they take no account of a small number of cases in which no apparent clinical response to œstrogens takes place. In such instances the persistence of an elevated serum acid phosphatase value, despite massive doses of œstrogens, suggests that prostatic epithelial activity remains unchecked and the histological picture correspondingly unaltered. Although not invariably raised, we have found the serum acid phosphatase value to be the most reliable criterion of reaction to œstrogen therapy, and depend on it in preference to the mammary changes, pigmentation, and other side effects. That it represents the general response of both primary and secondary deposits is suggested by the fact that, in a number of prostatic fragments which we examined, the phosphatase content bore no constant relation to the serum value.

Further evidence of this production of acid phosphatase by metastatic deposits is furnished by the following case :—

A patient aged 71 suffering from prostatic carcinoma was found to have metastases in the inguinal and axillary lymph-glands. Two adjacent glands of comparable size in the right axilla were particularly hard and discrete. One of these was removed at the commencement of treatment with dienœstrol and the other three weeks later, by which time it had become appreciably smaller and softer. In the meantime, the serum acid phosphatase value had fallen from 6·2 to 0·8 units per c.c. Both glands were fixed by similar methods, and the sections obtained stained simultaneously to show, on the one hand, the histological structure, and on the other, the acid phosphatase content. The comparative histology (*Fig.* 153) closely resembled that previously found in prostatic tissue. The glandular structure in each case was replaced by neoplastic tissue to an almost corresponding extent, but whereas in the first gland the tumour units and their constituent cells were large, those in the second gland appeared smaller and pyknotic. Sections stained by the method advocated by Gomori (1941) showed the presence of acid phosphatase in both cases, but with a considerable reduction in the second gland. Whereas in the first gland every neoplastic cell appeared to elaborate the phosphatase, many areas of growth in the second gland failed to

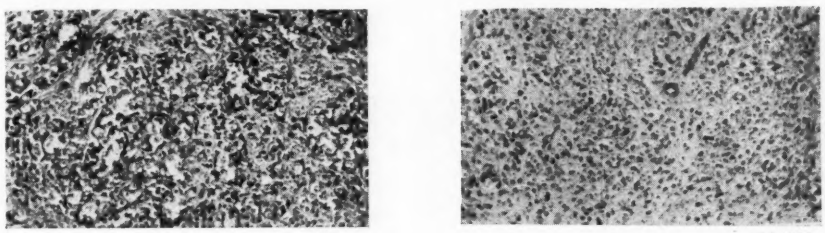

FIG. 153.—Microphotograph of sections from two axillary glands showing secondary carcinomatous invasion. The glands were removed at intervals of twenty-four days from a patient receiving dienœstrol. (× 90.)

show its presence, and even where found it seemed to stain to a lesser degree (*Fig.* 154). In his survey of the distribution of acid phosphatase in the tissues Gomori states that normal lymph-glands contain

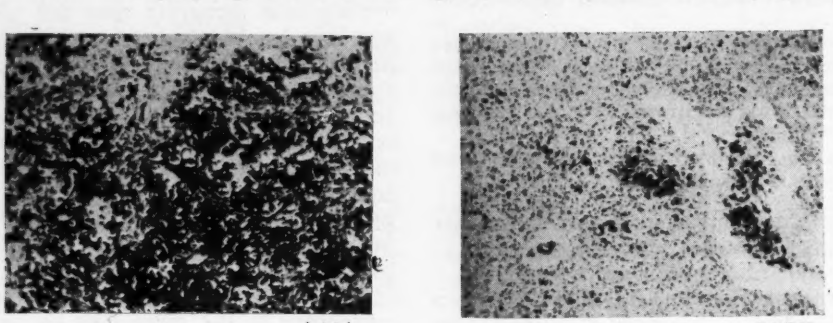

FIG. 154.—Microphotograph of sections taken from the two axillary glands depicted in *Fig.* 153, and stained to show acid phosphatase. (× 90.)

none, but that metastatic tissue from certain epithelial neoplasms, other than those of the prostate, may be positive.

Since we are unable to aver that both these glands were affected similarly by carcinoma in the first instance we make no claim as to the œstrogenic response in this case. We cite it merely to illustrate the production of acid phosphatase by metastases. Were it not for the probability that in carcinoma of the prostate such metastases only occur in conjunction with other unmistakable evidence of the disease, this method of phosphatase assay by glandular biopsy might prove of diagnostic significance in the differentiation from non-phosphatase-producing tumours.

SUMMARY

An attempt has been made to correlate the histological findings in serial perurethral biopsies of carcinomatous prostatic tissue with the clinical improvement noted during prolonged œstrogen therapy.

Mention is made of the mode of selection of cases and attention drawn to certain features which may render repeated examination impracticable.

The importance of comprehensive clinical, biochemical, and radiographic records, as an index of the œstrogenic response, is stressed; and description given of the method by which the biopsy material has been obtained. Carcinomatous prostatic tissue removed at intervals varying from six months to two-and-a-half years from five patients receiving œstrogens, has been examined histologically. Microscopical changes showing a diminution in number and size of the tumour units, together with cytological changes including a reduction in the nuclear diameter, were observed in the later material.

The value of acid serum phosphatase estimation in assessing the course of the disease is alluded to, and mention made of a case in which phosphatase was demonstrated in glandular metastases.

We are particularly indebted to Miss M. Smith for her assistance in carrying out the exhaustive measurements of the nuclear diameters and in the computation of the tumour units. We would also express our thanks to Mr. J. Mayhew for his assistance in the preparation of the histological material, and to Miss H. Saxl, who has been responsible for the microphotography.

REFERENCES

FERGUSSON, J. D. (1944), *Lancet*, **1**, 595.
GOMORI, G (1941), *Arch. Pathol.*, **32**, 189.
HUGGINS, C., SCOTT, W. W., HODGES, C. V. (1941), *J. Urol.*, **46**, 997.
MCGAVIN, D. (1938), *St. Bart.'s Hosp. Rep.*, **71**, 209.
MOORE, R. A. (1935), *J. Urol.*, **33**, 224.
RICHES, E. W. (1943), *Brit. J. Surg.*, **31**, 135.
— — (1944), *Middlesex Hosp. J.*, **44**, 23.
SCHENKEN, J. R., BURNS, E. L., KAHLE, P. J. (1942), *J. Urol.*, **48**, 99.
THOMPSON, G. J. (1942), *J. Amer. med. Ass.*, **120**, 1105.

A HISTOLOGICAL STUDY OF A PREDEGENERATED NERVE AUTOGRAFT

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ENOUGH evidence has accumulated to show that autografts are the only type of nerve-graft which can be used in man with any hope of success. The successful results of autografting have almost without exception been cases where the gap in the nerve could be bridged by a graft of small calibre as in the facial or digital nerves (Duel, 1933; Bunnell and Boyes, 1939; Collier, 1940), or in the larger nerve-trunks by a cable graft. Even under the most favourable conditions a cable graft will provide only a very indifferent pathway for the new nerve-fibres. Occasionally it may be possible to procure a graft comparable in diameter to the injured nerve. For instance, when a patient has suffered an amputation as well as an extensive nerve injury a nerve can be removed from the amputation stump,

or, if there are large gaps in two nerve-trunks, a segment from the less important nerve may be used to bridge the gap in the other (Seddon and Holmes, 1944).

In this case an experimental autograft was performed in a patient in which it was impossible to bridge a very large gap in an ulnar nerve. The graft was taken from the distal end of the damaged ulnar nerve and sutured to the central stump. Five and a half months later the graft was excised and examined histologically. This enabled us to study: (1) The histological condition of an autograft predegenerated for a long period—in particular, its ability to survive without necrosis and to receive and conduct nerve-fibres; and (2) The regenerative capacity of the central stump after a similar long interval. The only other full histological account of an innervated human autograft is that of Seddon, Young, and Holmes (1942).

CASE REPORT

HISTORY.—J. W., aged 27, was wounded on March 9, 1941, by a machine-gun bullet. He suffered an extensive wound of the soft tissues over the inner side of the right elbow-joint with comminution of the lower end of the humerus and upper ends of the radius and ulna, and a complete lesion of the ulnar nerve. Several days elapsed before he could be given definitive treatment, and the wound became heavily infected. It was not until one year later that the wound was soundly healed. On Oct. 16, 1942, he was admitted to the Nerve Injury Unit at the Winwick Emergency Hospital. The elbow-joint was ankylosed in a position of 20° below the right angle. There was an extensive scar involving the skin and soft tissues over the inner side of the joint, and no evidence of any recovery of the ulnar nerve lesion. Exploration of the nerve was advised, although it seemed unlikely that a successful repair could be performed.

FIRST OPERATION (Nov. 12, 1942), 613 days after injury.—Under general anæsthesia an incision was made from the axilla to the lower third of the forearm.

Condition of Nerve.—

Central Stump: There was a large end bulb 8 cm. above the elbow. From there the nerve gradually tapered until at a point 10 cm. above the bulb it became of normal diameter. This portion of the nerve was distinctly firmer than usual; 10 cm. of the central stump was resected.

Histological examination: There are numerous bundles with well-preserved axons and myelin sheaths, but in a few of the bundles some of the nerve-fibres show swelling of the axons and fragmentation of the myelin sheath. The perineurium of the affected bundles is somewhat thickened. There is some œdema of the interfascicular connective tissue and the bundles are more widely spaced than in normal nerve.

Peripheral Stump: The peripheral stump terminated in scar tissue 6 cm. below the elbow-joint. It was necessary to resect about 3 cm. of the central end of the peripheral stump to expose 'normal' nerve-bundles.

Histological examination: Well-defined nerve-bundles separated by increased interfascicular connective tissue. The bundles themselves are shrunken and there is no evidence of axons or myelin sheaths.

Grafting.—It was evident that suture of the nerve could not be performed even after anterior transposition, and a cable autograft was equally impossible. It was decided, therefore, to perform an experimental autograft. 7 cm. of the distal end of the nerve were excised and sutured to the central stump with three fine linen thread sutures which were passed only through the sheath of the nerve. Owing to the difference in the diameter of the graft (3 mm.) and the central stump (6 mm.), only about 25 per cent contact between the stump and the graft was obtained. The distal end of the graft was sutured to the intermuscular septum. There was little or no scarring of the soft tissues on which the graft lay.

SECOND OPERATION (April 29, 1943), 168 days after insertion of the graft.—Under local anæsthesia an incision was made in the line of the graft. The graft was readily identified; a good junction had apparently been made between it and the central stump. There was a fusiform swelling at the suture line which was distinctly firmer than the nerve above. The graft itself appeared to be firmer than at the time of insertion; it was not unduly adherent to the surrounding tissues.

The graft was stimulated with a faradic current but no sensory response was obtained distal to a point 1 cm. below the suture line.

The entire graft was excised together with a further 2 cm. of nerve from the central stump and retained for histological examination.

Material taken out for histological examination was fixed in formol-saline, cut in blocks of 10–15 mm., and embedded in paraffin. Cross-sections were cut at 5μ, 10μ, and 20μ from each block and stained by one of the following methods: hæmalum and eosin, Mallory's triple stain, modified protargol, or a modified Weigert method. Finally, each block was sectioned longitudinally at 10μ and sections were mounted in two series. Modified protargol method was used for one series and hæmalum and eosin staining for the other.

Central Stump: There is no epineurium. The interfascicular connective tissue is decidedly fibrous and there is no evidence of the loose connective tissue with occasional fat cells normally found in the larger human nerves. The perineurium is distinct and well developed. The sections show a sufficient number of healthy bundles to ensure regeneration (*Fig.* 155). In most of the fascicles the majority of nerve-fibres are well myelinated with

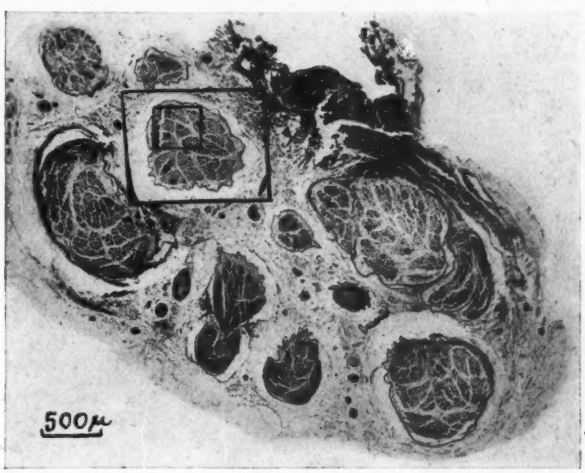

FIG. 155.—Central stump. Cross-section. Modified protargol method.

the normal proportion of non-myelinated fibres (*Figs.* 156, 157). In longitudinal sections it can be seen that the majority of myelinated fibres lose their myelin sheath at about 2 mm. from the suture line. This may mark the extent of retrograde degeneration after the resection of the neuroma of the central stump at the first operation. Above that limit the myelin sheath of the medullated fibres is normal. Inside the fascicles there is a slight degree of intrafascicular collagenization under the perineurium and in the form of thickened endoneurial septa (*Fig.* 158). No proliferation of Schwann cells can be seen and only a few macrophages. Numerous large blood-vessels are present in the interfascicular tissue,

but few capillaries. The fairly numerous peripheral hæmorrhagic areas can probably be attributed to handling at operation.

Graft Junction: There is good tissue junction. In the longitudinal silver-stained sections (*Fig.* 159) the nerve-fibres can be traced from the central stump through the junction into the nerve-bundles of the graft. At the level of the junction there is much irregularity and criss-crossing of fibres and a large number of aberrant fibres

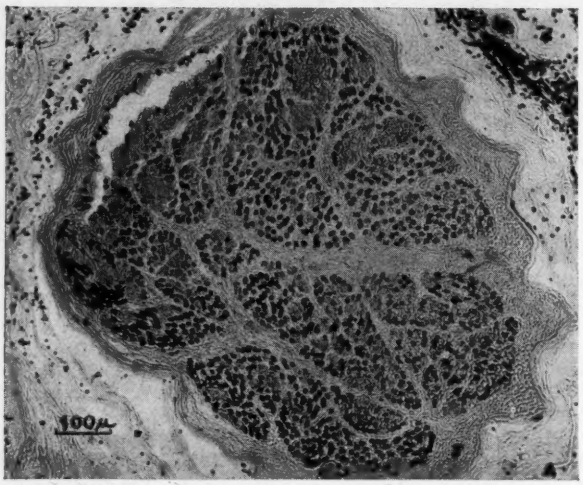

FIG. 156.—Central stump. Cross-section of bundle indicated by large square in *Fig.* 155. Modified Weigert staining.

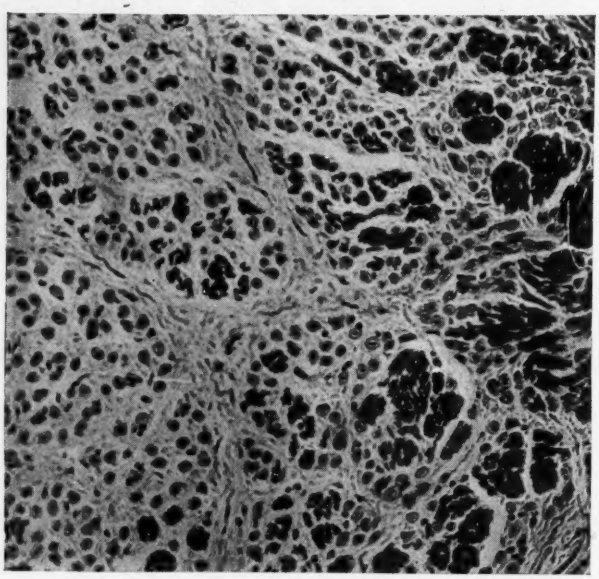

FIG. 157.—Central stump. Cross-section representing area of small square of *Fig.* 155. Clusters of non-myelinated fibres in right side of the field. Modified protargol method.

but no Perroncito spindles (*Fig.* 160). Some medullated fibres can be followed almost to the suture line. The hæmalum and eosin and triple-stained sections show hæmorrhagic areas, a large amount of fibrous tissue, and Schwann nuclear proliferation. In the neighbourhood of the suture line there are round-cell infiltrations and occasional foreign-body giant cells.

Graft Tissue: Bundles of nerve-fibres can be followed throughout the whole length of the graft (*Fig.* 161). The bundles are smaller and more numerous than in the central stump (*Fig.* 162), which may in part be due to the fact that the graft represents a more peripheral portion

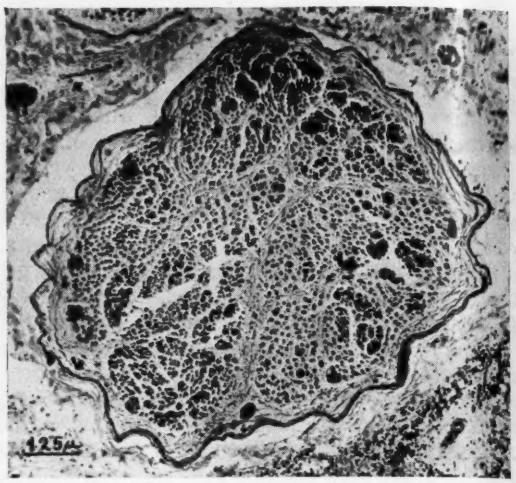

FIG. 158.—Central stump. Cross-section representing area of large square of *Fig.* 155. Noticeable intrafascicular fibrosis. Modified protargol method.

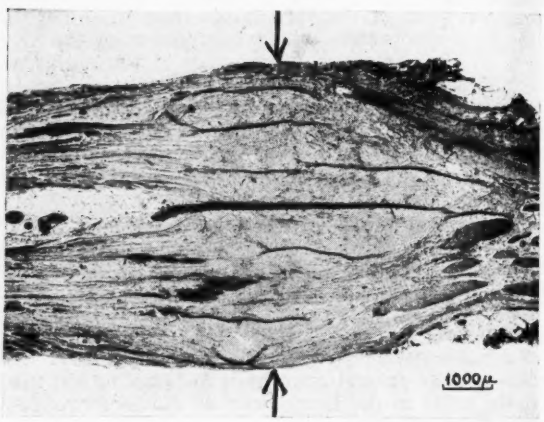

FIG. 159.—Junction of graft with central stump. Longitudinal section. Central stump left side, graft right side; arrows mark level of suture line. Modified protargol method.

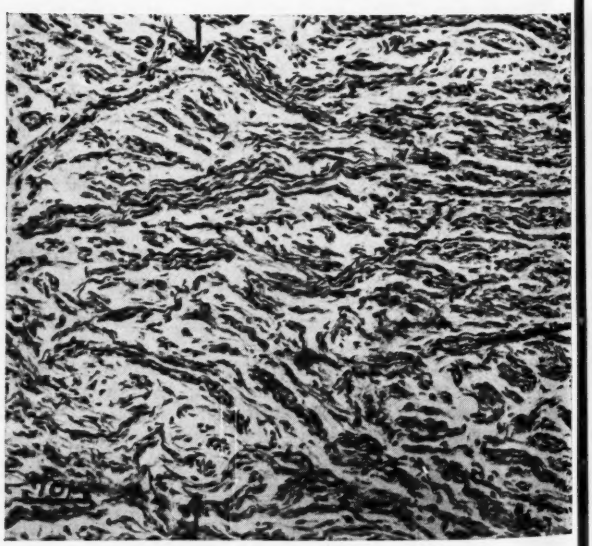

FIG. 160.—Junction of graft with central stump. Longitudinal section. Central stump left side, graft right side; arrows mark approximate level of suture line. Modified protargol method.

FIG. 161.—Graft. Longitudinal section of bundle indicated in *Fig.* 162 to show presence of nerve-fibres. Modified protargol method.

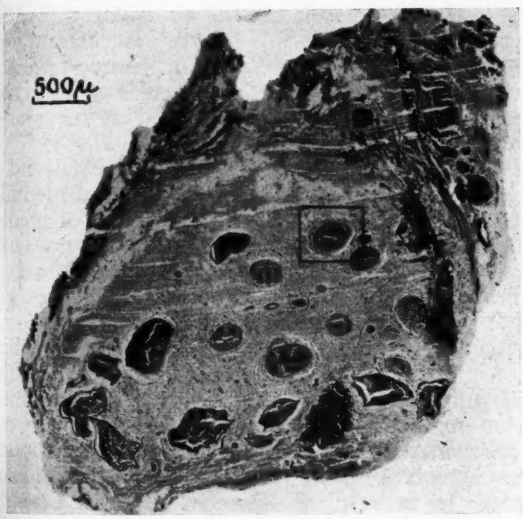

FIG. 162.—Graft. Cross-section. Compare with *Fig.* 155. Modified protargol method.

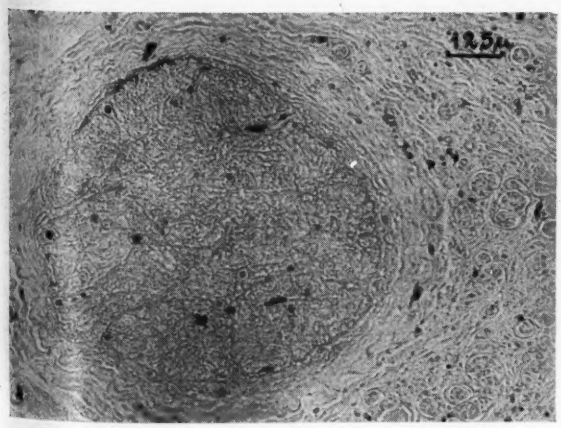

FIG. 163.—Graft. Cross-section of bundle indicated in in *Fig.* 162. Compare with *Fig.* 156. Absence of staining denotes lack of myelination. Modified Weigert staining.

of the nerve where normally some decrease in the size of the bundles is to be expected. The new fibres have progressed along the old bundles which for the most

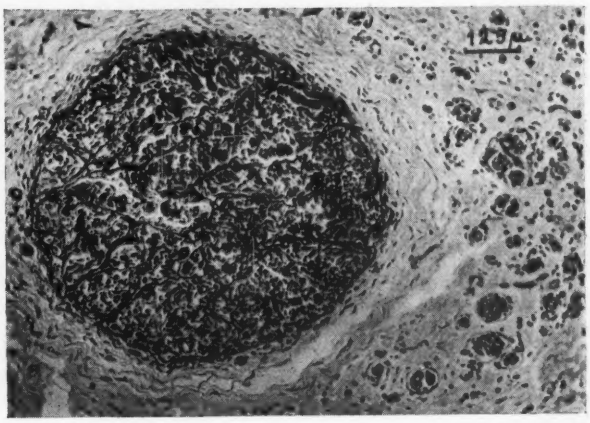

FIG. 164.—Graft. Cross-section representing area marked in *Fig.* 162. Densely packed non-myelinated fibres inside fascicle. Numerous aberrant fibres in right side of field forming small fascicles. Compare with *Fig.* 158. Modified protargol method.

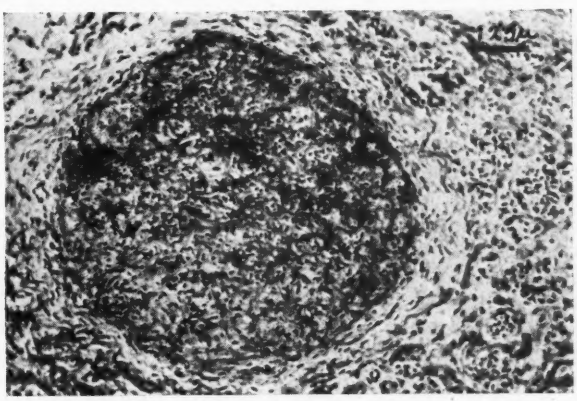

FIG. 165.—Graft. Cross-section. Well-marked intrafascicular collagenization. Section of the same bundle as *Figs.* 163, 164. Hæmalum and eosin staining.

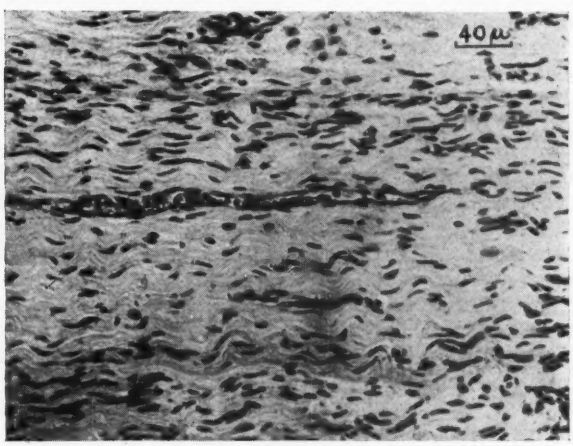

FIG. 166.—Graft. Longitudinal section to show presence of Schwann-cell nuclei. Hæmalum and eosin staining.

part are densely packed with regenerating axons. A few bundles, however, especially towards the middle and distal end of the graft, are but sparsely populated. None of the nerve-fibres in the graft is medullated (*Fig.* 163).

The transition from medullated to non-medullated fibres occurs abruptly immediately above the suture line. There are a number of aberrant nerve-fibres in the interfascicular fibrous tissue, which can be followed for about 20 mm. down the graft. Some of these have formed themselves in small bundles and have acquired a semblance of perineurium from a condensation of surrounding fibrous tissue (*Fig.* 164).

In cross-sections the nerve-bundles are rather widely spaced in a dense fibrous tissue (*Fig.* 162). There is no epineurium but a thickened lighter staining perineurium. The nerve-bundles contain a large quantity of densely packed collagenous fibres and the small nerve-fibres in the old nerve-tubes seem to be pressed upon and almost strangled in the midst of this intrafascicular fibrosis (*Fig.* 165).

A number of Schwann nuclei can be seen within the nerve-bundles in longitudinal sections (*Fig.* 166). There are no round-celled infiltrations and no necrotic areas in spite of the thickness of the graft which appears to have been adequately vascularized, probably in part from the central end and in part by ingrowth from adjacent vessels.

DISCUSSION

The interesting features in this case are: (1) The capacity of the central stump for regeneration after 613 days; (2) After a similar long period of degeneration an autograft can receive new nerve-fibres despite the fact that the histological condition was inimicable to their maturation; (3) Although the graft had a calibre of 3 mm. there was no central necrosis.

Central Stump: It can be assumed that the regenerative capacity of nerve-fibres is a property of the neuron. Neurons rendered functionless through separation from their end-organs ultimately undergo atrophy. This inactivity atrophy may affect a number of neurons during normal regeneration as pointed out by Heidenhain (1911): "Auch bei der normalen Regeneration des Nerven werden je nach den Umstanden bald mehr, bald weniger zahlreiche Fasern vom Wege abirren oder anderswie in ihrem Wachstum gehemmt werden (die Perroncito-schen Apparate sind offenbar Hemmungsbildungen); demgemass werden in den zugehorigen Ursprungs-zellen dauernde regenerative Erregungszustande auftreten, welche schliesslich zur Erschopfung und zum Schwunde des ganzen Neurons fuhren." It seems probable that in such neurons the regenera-tive power will gradually diminish and finally be lost. Collier (1940) discusses the work of Ballance, who found regressive changes in the facial nuclei and ultimate disappearance of the cells after facial nerve injury, and states: "What we do not know is how long it takes for these changes to become irreversible." We can, however, find no records which would enable us to hazard even an approxi-mate estimation of how long a functionless human neuron retains its regenerative power. Spielmeyer (1922) gives an illustration of a motor nerve-cell from the lumbar region of the spinal cord $1\frac{1}{2}$ years after leg amputation. The only change noted was a hyperchromatosis of Nissl's granules. He also confirms the statement of Bielchowsky that a much larger number of nerve-cells than would be expected survive after amputation. Holmes and Young (1942) record no decrease in the nerve-fibre out-growth from the central end of a rabbit nerve after a year and conclude that the power of outgrowth from the central stump does not diminish during the progressive formation of a neuroma. In our case the neurons had been functionless for 613 days yet retained their regenerative power. It can therefore be concluded that within the time span of the majority of nerve repair operations a healthy central stump will contain nerve-bundles capable of vigorous nerve-fibre outgrowth.

Graft: Even after prolonged degeneration the general architecture is preserved, although the nerve-bundles have contracted and are much smaller than normal.

Holmes and Young (1942) describe the condition of an isolated peripheral stump in rabbits after a year. They found preservation of the general structure—nerve-bundles and nerve (Schwann) tubes. The bundles were much smaller and the nerve-tubes, now less than half the size of a normal nerve-fibre, were separated by areas filled with collagenous tissue. These old peripheral stumps were still capable of receiving regenerating nerve-fibres, though some showed a diminished growth rate. They ascribe this retarded growth rate to a decline in the Schwann-cell outgrowth following delayed suture with a consequent imperfect junction, criss-crossing, and shunting of nerve-fibres. After 168 days it is not possible for us to assess the initial Schwann-cell outgrowth. There is certainly a considerable number of aberrant nerve-fibres at the junction, but a degree of irregularity and criss-crossing of fibres is to be expected at the site of suture.

The nerve-fibres have reached the distal end of the graft, but there is complete absence of medulla-tion. It is tempting to connect this lack of medul-lation with the inevitable failure of the nerve-fibres to reach their end-organs, but the results of animal experiments show that medullation commences well before the nerve-fibres have arrived at their final destination (Young, 1942; Bacsich and Wyburn, 1945). Holmes and Young (1942) found that after a delayed suture of the rabbit nerve (514 days) there was no medullation and they suggest that this is due to collagenization and narrowing of the Schwann tubes which prevent the necessary preliminary increase in nerve-fibre diameter. In our case the small nerve-fibres in the midst of the abundant collagenous tissue of the nerve-bundles of the graft would have little room for expansion and it seems probable that as in the rabbit nerve the non-medulla-tion can be attributed to the strangulating effect of intrafascicular fibrosis whereby there is no pre-myelination expansion of the nerve-fibres.

Seddon, Young, and Holmes (1942) describe the innervation of a fresh autograft of the human median nerve (examined after six months) by myelinated fibres which penetrated to the peripheral stump. The graft preserved its own bundles occupied by the regenerated axons, but there was marked intra-fascicular fibrosis.

Sanders (1942), in his review of the methods of repair of large nerve gaps, suggests that "Revascular-ization of a graft of large calibre may not occur with sufficient speed to allow proper Wallerian degenera-tion and the centre of the graft may become necrotic." In this case there was no necrosis, although it is possible that the degenerated autograft is less

vulnerable and more able to survive the initial critical period than the fresh autograft.

It is not easy to explain the negative response of the graft to faradic stimulation. It is possible that the graft was innervated largely by motor-fibres perhaps by reason of the limited contact (25 per cent) of graft and central stump. Spielmeyer (1922), however, points out that while the retrograde and regenerative changes of motor nerve-cells after injury to their axons are well recognized, little is known about the effect of axonal damage to the other types of nerve-cells. It is therefore possible that the sensory neurons may undergo more rapid inactivity atrophy than the motor neurons, in which case most of the regenerated nerve-fibres would be motor. Holmes and Young (1942) report a high threshold to faradic stimulation of the peripheral stump after delayed suture. It may be that this is the result of intrafascicular fibrosis. In our case the total lack of response can probably be attributed to a combination of these two factors—a preponderance of motor-fibres and collagenization of the nerve-bundles.

Sanders and Young (1942), in experiments with rabbit nerve, have confirmed the conclusion of Bentley and Hill (1936) that regeneration is not more rapid in predegenerated than in fresh autografts and that the only advantage of predegeneration is a firmer consistency and thus easier handling. Our results indicate, however, that this advantage would be more than counter-balanced by the disadvantage of a too prolonged predegeneration of an autograft.

SUMMARY

1. An autograft taken from the distal end of an ulnar nerve which had suffered an irreparable injury was sutured to the central stump, and removed 5½ months later for histological examination.

2. The central stump still retained regenerative capacity 613 days after injury.

3. The autograft survived and provided a pathway for new nerve-fibres, although none of these fibres was medullated.

4. The absence of medullation may have been due to extensive intrafascicular fibrosis which prevented normal maturation of the nerve-fibres.

5. There was no central necrosis of the autograft.

We wish to express our thanks to Dr. L. Pollak for the histological reports on the nerve-stumps excised at the first operation, and to Mr. A. S. Kerr who was associated with one of us in the care of the patient.

REFERENCES

BACSICH, P., and WYBURN, G. M. (1945), *J. Anat.*, **79**, pt. 2.
BENTLEY, F. H., and HILL, M. (1936), *Brit. J. Surg.*, **24**, 368.
BUNNELL, S. L., and BOYES, J. H. (1939), *Amer. J. Surg.*, **44**, 64.
COLLIER, J. (1940), *Lancet*, **2**, 91.
DUEL, A. B. (1933), *Surg. Gynec. Obstet.*, **56**, 382.
HEIDENHAIN, M. (1911), *Plasma und Zelle*, **2**, 880. Jena.
HOLMES, W., and YOUNG, J. Z. (1942), *J. Anat.*, **77**, 63.
SANDERS, F. K. (1942), *Brain*, **65**, 281.
— — and YOUNG, J. Z. (1942), *J. Anat.*, **76**, 10.
SEDDON, H. J., and HOLMES, W. (1944), *Surg. Gynec. Obstet.*, **79**, 342.
— — YOUNG, J. Z., and HOLMES, W. (1942), *Brit. J. Surg.*, **29**, 378.
SPIELMEYER, W. (1922), *Histopathologie des Nervensystems*. Berlin.
YOUNG, J. Z. (1942), *Physiol. Rev.*, **22**, 318.

OBSTRUCTIVE DIAPHRAGMATIC HERNIA RESULTING FROM OLD GUNSHOT WOUND OF THE CHEST

A REPORT OF THREE CASES

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DURING the present war the treatment of thoracic wounds has become increasingly conservative. Collections of blood or exudate in the pleural cavity are usually treated by repeated aspiration, and, in the absence of sepsis, thoracotomy is rarely performed except to remove large foreign bodies. If there has been no major mediastinal injury, transversing wounds by small high velocity missiles have done almost uniformly well, recovery has generally been complete, and the soldier has returned to duty.

But particularly in wounds of the lower chest, the diaphragm may be injured and abdominal viscera, especially the stomach and transverse colon, may be herniated into the thorax. Two such cases were recently admitted to neighbouring Base hospitals in the Middle East, each suffering from an obstructed diaphragmatic hernia of the colon as a late complication of a wound of the lower chest. Their case histories are presented in order to direct attention to the possibility of diaphragmatic hernia being latent until complications with a high mortality supervene. A third case, with herniation of the stomach, is reported from England.

CASE REPORTS

Case 1.—**Old abdomino-thoracic gunshot wound; diaphragmatic hernia; intestinal obstruction.**

On Nov. 15, 1942, Tpr. H., aged 23, sustained a gunshot wound of the right side of the thorax between the 7th and 8th ribs, a little anterior to the mid-axillary line. The bullet finally lay subcutaneously at a corresponding point on the left side of the chest. It was removed and recovery was at first uneventful.

He was discharged to Convalescent Depot on Dec. 27. While at the Convalescent Depot, in mid-January, 1943, he had an attack of central abdominal pain and vomiting. This attack lasted only a few hours and he was discharged to duty early in February.

He remained symptom-free for nearly two months, when he had a second attack similar to the first, but lasting about a day.

The third attack, from which he ultimately died, began on April 20. Again he had central abdominal colic, with vomiting and constipation. As he did not improve in two days, during which he took fluids only, he was sent to a Field Ambulance with a provisional diagnosis of gastritis. On admission to the Field Ambulance the diagnosis was changed to subacute intestinal obstruction and the following notes were made :—

Bowels not open for some days, no abnormal tenderness, tongue slightly furred, chest nil except scar.

April 23 : Intermittent abdominal pain and occasional vomiting. Fluids only. Pulv. alk. and belladonna.

April 24 : T. 99° ; P. 72. Pain in lower abdomen, colicky in nature. Abdomen distended and tympanitic. Some resistance right side. Enema—no result except a little flatus. W.B.C., 20,900 ; 77 per cent polymorphs.

April 25 : T. 99° ; P. 100. A little flatus passed. Still having colicky pain and returning fluid taken effortlessly.

The decision was now taken to evacuate the patient to a general hospital by ambulance car. The lateness of this decision may have been due in part to the fact that the distance was considerable, over difficult roads. The journey took nearly twelve hours, and during the trip there was copious vomiting of brown fluid.

At 23·00 hours he arrived, ill and dehydrated, at the general hospital. Admission note : " Cheeks slightly sunken, tongue slightly moist and clean. Abdomen somewhat distended and tympanitic above umbilicus. Large slightly tender mass in right iliac fossa. Intestinal sounds markedly increased in all areas. Rectally no abnormality detected. Some rather dry fæces in rectum. Lungs : Percussion note and breath sounds normal in all areas. T. 97·4° ; P. 96. Continuous intravenous saline instituted. Morphine (gr. ¼)."

The following morning, April 26, the diagnosis of advanced intestinal obstruction was self-evident. General abdominal distension, ladder pattern ; colicky pains. No vomiting since admission ; rehydration satisfactory.

OPERATION, 11.00 hr. (W. A. M.).—Anæsthesia : Spinal stovaine 2 c.c. Left paramedian laparotomy. General distension of small bowel except for proximal 2 ft. of jejunum. Stomach empty. Small bowel plum coloured. Enormous distension of cæcum and ascending and transverse colon. Obstruction by diaphragmatic hernia of splenic flexure and part of transverse colon.

To gain access to the hernia it was necessary to make a secondary oblique incision from just above the umbilicus to the subcostal margin in the neighbourhood of the 10th left costal cartilage. The cartilaginous margin was divided and the incision continued, to open the pleural cavity. The tight hernial ring situated centrally in the left dome of the diaphragm was enlarged by a radial incision and the herniated mass, consisting of 18 in. of colon and almost all of the great omentum, was returned to the abdominal cavity. The colon was clearly viable but the omental mass was in part necrotic and so it was removed. Diaphragmatic opening closed with interrupted sutures of heavy catgut with an overlay of fine catgut. Closure of the abdominal incision proved difficult, and it was necessary at this stage to give ether. The anal sphincter was stretched and a rectal tube inserted allowing escape of a considerable volume of foul black fluid fæces which had passed onward following relief of the obstruction.

During the course of the operation the patient had two pints of blood and one pint of glucose-saline. His final condition was satisfactory, but he was ' chesty '.

PROGRESS.—Following operation, his condition steadily deteriorated. He presented persistent and resistant cyanosis, much bronchial fluid, and there were signs of peripheral vascular failure. Venoclysis was discontinued. Continuous oxygen administered with partial good effect. Coramine in adequate dosage had no appreciable effect. Morphine (gr. ¼) was given with atropine (gr. $\frac{1}{100}$). Deterioration, however, continued throughout the day, pulse-rate varying from 140 to 180 per minute and pulse volume very variable.

The following morning, April 27, at 05.00 hr. signs of impending death were apparent. Marked peripheral vascular failure and noisy dyspnœa. Partial left pneumothorax noted. 500 c.c. air withdrawn from left chest with diminution of signs of pneumothorax and temporary improvement of pulse, which became steady at 140 per minute. Glucose-saline venoclysis recommended and morphine and coramine repeated.

At 06.45 hr. he regurgitated unaltered a few ounces of water which he had drunk since operation and cardiac respiratory action ceased.

AUTOPSY.—This was carried out at 10.00 hr. by Major S. C. Buck, R.A.M.C., who reports as follows: " Well-developed muscular man. Rigor mortis present throughout. Dark red frothy fluid issuing in large quantities from mouth and nose. Sutured left paramedian wound, with subcostal extension.

" Peritoneal cavity contains about 15 oz. of blood-stained fluid. All coils of small bowel matted by light fibrinous exudate. Serous surfaces congested, with scattered subserous hæmorrhages. Mucosa œdematous in proximal part. Moderate distension of all except lowest 40 cm. of ileum. Colon contains dark fæces throughout ; serous surface of transverse colon shows a few small dark hæmorrhagic patches. Mucosa of this part markedly œdematous, giving the appearance of colourless jelly.

" Sutured wound about 8 cm. in left dome of diaphragm. The diaphragm is adherent to the left lobe of the liver and the chest wall deep to an old linear scar 1·5 cm. long in the skin over the 8th left intercostal space. Similar adhesions between right dome of diaphragm and right lobe of liver and chest wall, corresponding with a circular scar, 0·4 cm. in diameter, in right chest wall. Section of liver shows just visible fibrosis along old missile tract.

" About 8 oz. of blood-stained fluid in left pleural cavity. Left lung quite free, collapsed, and almost entirely airless. On section dark red fluid flows copiously. Right lung moderately well aerated except for lower lobe, which exactly resembles left lung. Right pleural cavity obliterated in lowest part by fibrosis extending as high as 4th rib in paravertebral gutter.

" Remaining abdominal organs congested but otherwise normal. Bladder distended. Brain not examined.

" *Cause of Death* : Old gunshot wound, thorax and upper abdomen. Operation : Reduction and repair of traumatic diaphragmatic hernia (left). Paralytic ileus and respiratory embarrassment."

Case 2.—**Old abdomino-thoracic shell wound ; diaphragmatic hernia ; intestinal obstruction.**

In 1940, during the battle of France, Bdr. V., aged 22, was wounded in the left side of the chest. He was evacuated to England and made an uninterrupted recovery, returning to duty as an A1 soldier. He then remained well until January, 1943, when he had an attack of severe colicky abdominal pain with vomiting and absolute constipation, which lasted for five days and from which he made a complete recovery. The attack ceased abruptly when he passed a large quantity of flatus.

His second and fatal attack began on June 23, 1943, when, after strenuous exercise, he was seized with severe abdominal pain, colicky in character, and vomited several times without obtaining relief.

On June 24 he was admitted to a Field Ambulance and the next day two enemata were given without result. It was then realized that he was suffering from intestinal

obstruction and he was transferred to the Base hospital. During this initial 48-hours' period of his illness colicky circum-umbilical abdominal pain had persisted. He had continued frequently to vomit and he could pass neither fæces nor flatus.

ON ADMISSION.—The patient's general condition was surprisingly good. T. 98·4°; P. 84. Tongue was moist but slightly furred. The abdomen presented slight epigastric distension; there was no rigidity, but there was some deep tenderness in the epigastrium and right iliac fossa. Peristalsis could not be seen and the potential hernia orifices were empty.

Per rectum nothing abnormal was found.

Chest: Apex beat was well medial to the left nipple in the 5th interspace, although it was 3½ in. from the midline. There were no abnormal cardiac sounds. There was a scar 1½ in. long in the left 7th interspace at the anterior axillary line (scar of the shell wound sustained in France in 1940).

Lungs showed slight diminution in breath signs over the left base.

Screen examination and radiograph revealed the presence of a hernia through the left dome of the diaphragm with a distended coil of large intestine inside the left pleural cavity. There was also marked dilatation of the colon below the diaphragm proximal to the hernia. A small piece of shell splinter was present in the right lobe of the liver.

PROGRESS.—On admission a continuous intravenous saline drip was instituted. An enema was given from which there was no return of fæces, and continuous gastric suction was begun.

The next day, June 26, he was more comfortable; he was free from pain and had passed flatus per rectum.

During the next two days, June 27 and 28, his condition remained good; he continued to pass flatus per rectum, and it was hoped that he would overcome this his second crisis of acute intestinal obstruction. However, on the evening of June 28 his temperature rose to 100° F., and the pulse-rate to 100. There was some increase in abdominal pain and his condition was not so good.

By the early morning of June 29 his condition had further deteriorated, and there was increasing abdominal distension.

Cæcostomy was performed, but it did not function efficiently. He continued to deteriorate and died in the early hours of June 30, after his temperature had risen to 105° F.

AUTOPSY.—This was carried out by Major H. A. Magnus, R.A.M.C., who reports as follows: "Well-developed, muscular man. Rigor mortis present, and there was a small old linear scar in the left 7th intercostal space and recent incision in the right iliac fossa. No evidence of peritonitis, but the small intestine greatly distended and congested.

"Diaphragmatic hernia: The left half of the transverse colon and the splenic flexure pass through a hole in the left dome of the diaphragm into the left pleural cavity. The whole of the intrathoracic portion of the colon is greatly distended, as is also the proximal colon, including the cæcum. The colon distal to the hernia is empty and contracted. The hole in the diaphragm is round and 4·0 cm. in diameter, situated in the muscular part of the left dome, slightly to the right of its centre. The efferent limb of the herniated colon is densely adherent to the edge of the hole in the diaphragm on its upper surface, and compressed against the edge of this hole by the tense and distended afferent limb of the herniated colon. At the neck of the sac the descending portion is compressed, partly by adhesions and partly by the pressure of the greatly distended afferent limb. There is no infection round the cæcostomy.

"Liver of normal consistency. A small piece of shell is firmly embedded in the upper surface of the right lobe.

"Right pleural cavity and contents normal. Left pleural cavity contains a small quantity of fluid and the left lung is pushed upward and medially and partially collapsed by the greatly distended intrathoracic portion of the large bowel. No evidence of infection of the left pleural cavity. The remaining organs are normal.

"*Cause of Death*: Old shell wound of thorax and upper abdomen; paralytic ileus secondary to obstruction of large bowel, herniated into thorax."

Case 3.—**Old penetrating bomb wound (mortar) of left chest; diaphragmatic hernia.**

Pte. McC., aged 19, was wounded in France shortly after D day, June 19, 1944. A small fragment of mortar bomb traversed his left arm, injuring the median and ulnar nerves, entered the left thorax, and lodged toward the back of the left chest cavity. Radiography of the chest showed a small hæmothorax. He made an apparently uncomplicated recovery and was shortly transferred to a neurological centre for treatment of his nerve lesion.

In September, 1944, an operation was performed on his left arm. In the immediate post-operative period he had fairly severe epigastric pain. This subsided after a few hours, but recurred some days later and thereafter with increasing frequency until it was practically a daily occurrence. He went on sick-leave on Jan. 8, 1945. While on leave he began to vomit and thereafter vomited practically everything he ate.

He was admitted to an E.M.S. hospital in the south of England on Jan. 15. His admission note states: "Pale, ill, and wasted. Slight tubularity of breathing in right axilla. Abdomen N.A.D."

On Jan. 17, he was X-rayed, and the following report made: "Left dome of diaphragm high. No pulmonary lesion. Paravertebral foreign body present. Stomach appearances suggest 'cup and spill' stomach." Blood-count showed a slight degree of anæmia, but no significant abnormality.

On Jan. 25 he was X-rayed again with barium. On this occasion the stomach did not show the 'cup and spill' appearance, but barium was still present in the stomach after 8 hours. Examination of the fæces for occult blood was negative. While in hospital his general condition did not improve, and on Jan. 30 he began to vomit dark-brown fluid containing altered blood and deteriorated rapidly. On Jan. 31 he was seen in consultation by one of us (W. A. M.) at 15.10 hr. He was retching and bringing up small amounts of dark-brown fluid, and complaining of intense thirst. He was pale and obviously dehydrated. T. 99°; pulse-rate 90, and small in volume. Values for blood-urea (48 mg. per cent) and blood-chlorides (262 mg. per cent) became available at this time. A clinical diagnosis of post-traumatic diaphragmatic hernia was made and study of previous X-ray films confirmed the diagnosis, for the barium meal pictures of Jan. 18., 1945, indicated that at that time the greater part of the stomach was intrathoracic.

Glucose-saline venoclysis was begun and the patient was transferred by ambulance to a military hospital. In the course of the journey he received 2 pints of saline intravenously and his condition improved somewhat. Condition on admission: T. 97·4°; P. 76; R. 20. Venoclysis continued. Four pints of saline were given followed by 1 pint of plasma. It was desired to estimate the urinary chlorides, but unfortunately despite careful instructions the specimen passed at this time was discarded.

At 20.00 hr. a tube was passed transnasally into the stomach and suction drainage established. About a pint and a half of brown fluid was aspirated. Further X-ray examination showed the herniation of the stomach to be still present though comparatively small in size, and the stomach tube directed upward into the left hypochondrium toward the presumed opening in the diaphragm.

At 22.00 hr. hydration appeared complete. T. 97·2°; P. 80; R. 20; B.P. 120/94 mm. Hg. Pulse full, colour

good. Operation was performed at 22.15 hr. under intratracheal anæsthesia. The 9th left rib was resected and the thorax opened. There was an opening 4 cm. in diameter in the left dome of the diaphragm and through this there projected upward a hernial sac composed of omentum and containing the greater part of the stomach. There was one small adhesion to the lower margin of the lung and the stomach wall was densely adherent to parts of the margin of the hernial ring, in the neighbourhood of which there was much inflammatory œdema. The opening was slightly enlarged, adhesions divided, and stomach and omentum reduced into the abdominal cavity. The diaphragm was closed with interrupted sutures of stout silk, with an overlay of catgut. It was not necessary to interfere with the phrenic nerve. A catheter was introduced through the 10th space into the costophrenic sulcus, and after complete inflation of the lung the thoracic wall was closed in layers. A pint of blood was given during the operation and the patient left the table in good condition. Venoclysis and gastric aspiration were continued for 24 hours. The intercostal catheter was removed in 48 hours. Recovery was uneventful. On Feb. 13 four ounces of serous fluid were aspirated from the pleural cavity.

X-ray Appearances.—From a large series three radiographs are shown, taken on July 3, 1944, Jan. 18, 1945, and Jan. 31 (*Figs.* 167–169). It is easy to be wise in retrospect, but it may fairly be suggested that even on July 3, 1944, diaphragmatic hernia should have been suspected, for in addition to the presence of a small amount of fluid at the left base the film shows a well-defined air-containing sacculation extending considerably higher than the normal level of the left dome of the diaphragm. That of Jan. 18, taken after administration of barium, shows clearly the greater part of the stomach, ballooned out by gas and fluid with a little barium, in the thorax, the œsophagus dilated and ending in a saccular cardia with two fluid levels, and the pyloric antrum dropping straight down to the duodenum, dragging it to the left. The pre-operative radiograph on Jan. 31, after aspiration of the stomach, shows persistence of the gastric herniation and the transnasal tube curving up and to the left.

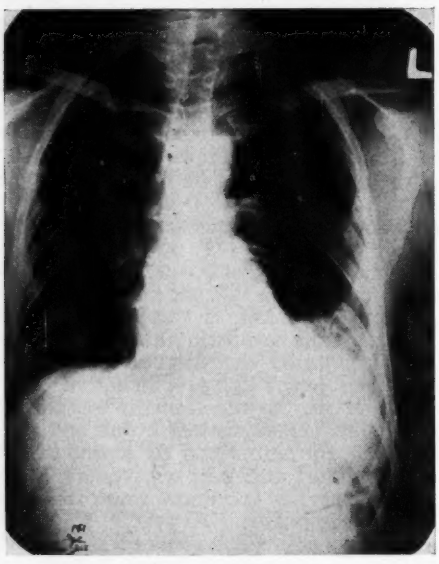

FIG. 167.—Radiograph taken on July 3, 1944, showing considerable opacity in left lower chest, in the upper portion of which a gas-containing cavity is seen.

Comment.—Experience of the two previous cases made a clinical diagnosis in this case easy and it was material in deciding upon operative intervention as soon as fluid and salt balance was restored. The operative procedure proved extremely simple as intrathoracic adhesions were slight. Intratracheal anæsthesia gave control of the lung, and by its means, reinforced by post-operative breathing exercises, it was possible to avoid any post-operative pulmonary complication. The small metallic foreign body did not present, and no search was made for it. Swinney (1942) reports a case of gastric diaphragmatic hernia following a knife wound. Conservative measures failed utterly and the patient was cured by thoracotomy and reduction and repair of the hernia.

FIG. 168.—Radiograph taken on Jan. 18, 1945. The œsophagus, filled with barium, is dilated, and terminates in a small spherical sacculation (the cardia), showing a double fluid level, of fluid and heavier barium. Above and to the patient's left is a great sac consisting of the greater part of the patient's stomach filled with gas, fluid, and a little barium. This communicates by a narrow neck with the pyloric portion of the stomach below. Metallic foreign body is clearly seen.

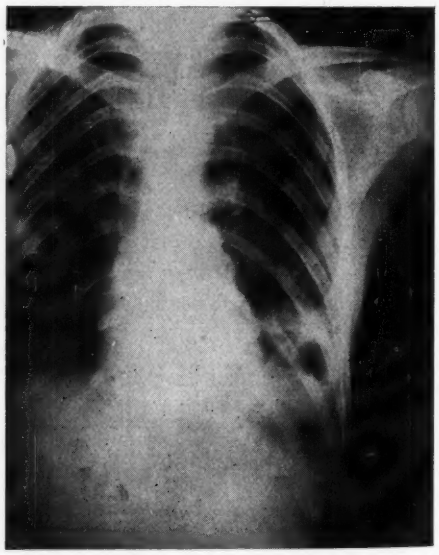

FIG. 169.—Pre-operative radiograph on Jan. 31, 1945. The fundus of the stomach is clearly seen above the diaphragm and the intragastric tube is seen curling upward and to the left.

DISCUSSION

Three cases are reported of diaphragmatic hernia following wounds of the lower thorax sustained some time previously. All were acutely ill when first seen, suffering from obstruction bordering on strangulation. One, in which the stomach had herniated into the thorax, recovered uneventfully following operation and need not be considered further. Two, in which the colon was involved, died. It may be profitable to attempt to assess the factors which contributed to the fatal issues. The following observations are offered :—

1. Diagnosis was delayed. In both cases the fatal attack was preceded by others which resolved spontaneously. Thorough investigation of these earlier illnesses would have established the diagnosis and might well have permitted repair during a relatively safe interval period.

2. In both cases, in the final illness, there was considerable delay before the patient was sent to hospital, in *Case* 1 five days, in *Case* 2 two and a half days.

3. In *Case* 1 the pre-operative diagnosis was incomplete. He was operated upon as a very ill emergency. But X-ray examination of the chest and abdomen would have completed the diagnosis, and had this been accomplished the thorax alone would have been opened and intratracheal anæsthesia used. Operation would have been shorter and less severe, collapse of the left lung would have been avoided, and he might well have recovered.

4. In *Case* 2 cæcostomy failed to benefit. Conservative measures appeared at first likely to be successful, but he suddenly deteriorated and cæcostomy was performed as a minimal emergency procedure. Its failure may be associated with the fact that it did nothing to relieve the obstruction, with partial strangulation, of the herniated loop.

It is fortunate that herniation of the colon through the diaphragm is rare, for it is associated with considerable risk to life. This is mainly because the lesion may readily set up two closed-loop obstructions, the distal being the herniated bowel inside the thoracic cavity, the proximal the colon between the ileocæcal valve and the hernial ring. In addition the herniated loop may be strangulated. The gravity of the proximal obstruction depends upon the fact that, if the ileocæcal valve remains competent, considerable pressures may be attained in the cæcum and proximal colon, which become enormously distended and suffer gross damage to mucosa and vasculature. It has been shown by Knight and Slome (1935) that obstructive distension of a loop of bowel results in compression of the blood-vessels in the mucosa. Absorption is slight during this phase, but toxic substances are elaborated in the lumen and gut wall, and these are freely absorbed if the pressure is suddenly relieved, with production of phenomena akin to 'shock'. Fatal toxæmia may therefore occur after a mechanically successful operative intervention. This toxæmia may have been a factor in producing the fatal issue in *Cases* 1 and 2.

It is not possible to state categorically what is the correct order of procedure in all cases of obstructed diaphragmatic hernia of the colon. It is possible that an early cæcostomy might relieve the acute emergency and permit of repair of the hernia in conditions of safety. Since, however, the herniated loop may be strangulated it is clearly dangerous to leave it unexplored unless the duration of the obstruction has been short, its degree incomplete, or the response, controlled by X-ray findings, to conservative measures such as gastric aspiration, cæcostomy, and venoclysis, entirely satisfactory. The correct approach to the hernia is by thoracotomy, and in the absence of obstruction or after its relief, reduction and repair of the hernia is a comparatively simple matter.

But as in all rare conditions, efficient treatment of traumatic diaphragmatic hernia depends mainly on sharp awareness of the possibility of its existence. It is probable that purposive investigation of all cases which have suffered a traversing injury of the lower thorax would bring to light unsuspected cases of diaphragmatic hernia. Barrett (1945) quotes a case in point. Certainly the occurrence of even mild obstructive symptoms should bring such cases at once under surgical care. It should then be possible, after accurate investigation, to carry out with precision the surgical measures necessary to save life.

SUMMARY

1. Three cases are presented of diaphragmatic hernia following missile wounds of the lower thorax.

2. Attention is drawn to the latency of the condition and to the gravity of its complications.

3. Some aspects of its management and treatment are briefly discussed.

REFERENCES

BARRETT, N. R. (1945), *Brit. J. Surg.*, **32**, 421.
KNIGHT, G. C., and SLOME, D. (1935), *Ibid.*, **23**, 820.
SWINNEY, J. (1942), *J. R. Army med. Cps.*, **79**, 297.

PELVIC ECTOPIC KIDNEY

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CONGENITAL abnormalities of the kidneys and ureters are comparatively common and, according to Gutierrez (1936), 40 per cent of all pathological conditions of those organs are due to congenital anomalies. A large proportion of these abnormalities fall into the category of renal dystopia. By definition, "an ectopic kidney is one that owes its position to developmental failure; it has been arrested in ascent during embryonic life and usually has failed to rotate" (Thompson and Pace, 1937). The

congenital displacement may affect one kidney, which is comparatively common, or may involve both, which is rare. Further, the dystopia may be crossed or uncrossed. The arrest in ascent may occur at any point along the normal course of the ureter, and the kidney or kidneys may be located in the lumbar region, on the iliac vessels, on the pelvic brim, or resting in the hollow of the sacrum. These positions, according to Brown (1931), correspond to the situations of the little ring muscles of the ureter described by Kelly. When both kidneys are ectopic or when crossed dystopia of one kidney is present, fusion of the kidneys to a greater or lesser extent commonly occurs. This leads to the production of horseshoe kidney with fusion at the upper or lower poles, or to the development of a 'concrescent' or 'cake' kidney, which may be found in the prevertebral region of the lumbar spine, situated to one or other side of the spine in crossed dystopia, or in the pelvis. When fusion occurs two ureters are present, as the conglomerate mass arises from the confluence of the primordia after the formation of the ureteric buds from the Wolffian ducts.

Unilateral pelvic ectopia of the kidney is not an extreme rarity, and several hundred cases of this condition have been reported in the literature. From time to time such cases are diagnosed clinically and the frequency of their ante-mortem discovery has greatly increased with the development of the cystoscope. In post-mortem material the incidence is certainly less than 1 in 2000 cases (*Table I*). Bilateral pelvic kidney is even less frequently encountered and is therefore a very rare condition indeed.

Table I.—Incidence of Unilateral Ectopic Pelvic Kidney

Author	Number of Cases	Number of Autopsies	Incidence Per 1000 Autopsies
Thompson, R. (1914)	1	13,505	0·07
Stewart and Lodge (1923)	3	6,500	0·46
Shore (1930)	1	1,464	0·68
Thomas and Barton (1936)	7	22,000	0·32
Thompson, G. J. and Pace (1937)	3	11,000	0·27

ANATOMICAL PECULIARITIES

The ectopic pelvic kidney is usually smaller than a normal kidney and is malformed. It may be moulded into the hollow of the sacrum or, if it lies on the iliac vessels, it will present a ridge on its posterior surface to accommodate those structures. Failure of normal axial rotation results in the hilum facing anteriorly, and, while the ureter is short and tortuous, it enters the bladder in the usual situation. The calibre of the ureter may be normal or may be less than average. The blood-supply is always abnormal, and it is this finding which, among others, distinguishes a congenital malposition from the usual type of ptosed kidney. The blood-supply is derived from the neighbouring arterial trunks and the aberrant vessels represent transient arteries which normally disappear as the kidney migrates to its position in the loin. These vessels spring from the external, internal, or common iliac arteries, and it is usual to find a renal artery arising near the bifurcation of the aorta. This vessel may replace the middle sacral artery or may be independent of it. Veins from the kidney drain into the iliac veins or into the lower end of the inferior vena cava. The normally placed kidney is held in position by the pressure of the 'intraperitoneal' abdominal organs, and by the perirenal fat. The ectopic pelvic kidney has no perirenal fatty capsule and its stability depends on its being retroperitoneal, on abnormal adhesions, or on the presence of more than one set of vessels entering the hilum from different directions. Sometimes the kidney may be found in the mesosigmoid or in the broad ligament (Herman, 1938) or, exceptionally, it may have a mesentery of its own (Ransohoff, 1920). Because of its separate embryological origin, the suprarenal gland on the affected side is normally situated but shows none of the moulding associated with its close apposition to the upper pole of the kidney.

EMBRYOLOGICAL THEORIES OF ECTOPIC PELVIC KIDNEY

The gross embryology of the upper genito-urinary tract is, in general, accepted as established and final. The ureteric buds appear in the 5-mm. human embryo and arise from the Wolffian ducts a short distance from their entrance into the cloaca. Each bud, which forms the collecting part of the kidney, grows into the metanephros, which forms a cellular cap on it and from which the secretory portion of the kidney is developed. The embryonic kidney, which at first is situated in the pelvis, ascends in the line of the degenerating mesonephros, undergoes axial rotation, and reaches its adult position by the end of the second month of intra-uterine life. The cause of this migration is not known. The theory that the ureteric bud pushes the metanephrogenic tissue upwards is not now generally accepted, and it may be that the ascent is more a matter of differential growth than true migration (Gruenwald, 1939). The ectopic pelvic kidney, therefore, represents an arrest in the normal ascent of the kidney and a corresponding failure in its axial rotation. It is clear that, whatever the cause, the defect must originate early in embryonic life and, due to the arrest, the temporary blood-supply becomes permanent.

The cause of the arrest is still the subject of discussion. One theory, attributed to Lemberger by Lucas (1934), is that it may be due to a failure of the ureters to elongate after a certain stage. This seems untenable, according to Brown (1931), who holds that early arrest in elongation of the ureters is accompanied by complete cessation of kidney development. This must depend on what is meant by 'early arrest' because an ectopic pelvic kidney has a short ureter and yet may function normally. It appears to be true that unless the ureteric bud makes contact with the metanephrogenic tissue, which is to form the secreting portion of the kidney, a normal functional kidney will not develop, suggesting, therefore, that the ureteric bud is concerned with organizing the differentiation of the

metanephros. A second theory (Lucas, 1934) is that excessive enlargement of the Wolffian bodies may cause their caudal ends to adhere to the metanephros and so may prevent the latter from detaching itself. Further, this hypertrophy of the Wolffian bodies may force the developing kidneys closer to the midline and into contact with one another, and it forms an attractive explanation of the origin of fused kidneys. There seems to be no theoretical objection to the postulation of unilateral hypertrophy of the Wolffian body thus retaining one kidney in the pelvis. A further theory (Carleton, 1937) is that anomalies in the origin of the umbilical artery may obstruct renal ascent. Ransohoff (1920) thinks that the arrest may be due to the abnormal origin of the renal artery from the iliac arteries. This opinion would not, I think, meet with general acceptance as it seems much more reasonable to suppose that the abnormal vascular supply is due to the ectopia and the survival of embryonic vessels than vice versa.

PATHOLOGICAL CHANGES IN PELVIC KIDNEYS

It is a generally accepted fact that if an organ is abnormally developed it is much more liable to disease than one of normal conformation and location. While this may be true, many pelvic kidneys cause no symptoms during life, and this accounts for the discrepancy between the incidence of their discovery clinically and at autopsy. In the series published by Thompson and Pace (1937), the clinical incidence of all forms of renal ectopy is estimated at about 1 in 10,000 cases, and that of the pelvic variety must be considerably less. The post-mortem incidence is in the neighbourhood of 1 in 2000 cases. The condition may be detected during a routine genito-urinary investigation or may be discovered in the course of a post-mortem dissection (De and Sinha, 1934; Pan, 1924; Shore, 1930; Smith and Boulgakow, 1925; and Gilman, 1927).

A pelvic kidney may cause dystocia but cases have been reported where normal delivery was achieved in spite of the additional pelvic organ. As the kidney lies in the pelvis on a similar level to the bladder, drainage from it is bound to be defective and, consequently, such an organ is more liable to infection and calculus formation than its normally placed fellow. According to Herman (1938), ectopic kidneys are predisposed to hydronephrosis and pyelonephritis, but there is no reason to suppose that they are more liable to tumours, tuberculosis, or injury than a normal kidney (Thompson and Pace, 1937).

Usually the kidney is firmly fixed in its abnormal position, but, if this is not so and it possesses a mesentery, torsion may occur. The only recorded case of this kind is that of Ransohoff (1920), where the kidney was suspended by a mesentery from the posterior pelvic wall and the gangrenous kidney was removed successfully by operation.

CASE REPORT

HISTORY.—A male child, which was born ten weeks premature and weighed 4½ lb. at birth, appeared to thrive and had no illness until he was two months old. During the first day of his illness he had diarrhœa, cried a lot, and kept drawing up his legs. He took all his feeds normally that day but during the night he was very restless and kept crying. Next day, the child took two feeds and appeared to be better, but in the early afternoon he was found dead in his cot.

AT AUTOPSY.—The child's body weighed 5 lb. 8 oz. and was 19 in. long. The left scapula was situated higher than usual, producing a deformity of the left shoulder, and the left side of the head and face was smaller and flatter than the right. No gross abnormality was noted on opening the abdomen, but when the bowel had been displaced a dark-purple retroperitoneal swelling

FIG. 170.—Post-mortem photograph. A, Left suprarenal gland; B, Left renal artery; C, Left renal vein; D, Left kidney; E, Left ureter; F, Bladder.

was noticed in the hollow of the sacrum. This swelling was suspended from the posterior wall of the pelvis by a short, twisted mesentery. Reduction of the torsion and further exploration of the abdomen revealed that the swelling was a deeply congested pelvic kidney. The right kidney and suprarenal were healthy and normally situated. The suprarenal occupied its normal position but was round and discoid instead of crescentic, presumably due to the absence of moulding on the upper pole of the kidney. The left kidney was flattened from hilum to lateral border in order to fit into the hollow of the sacrum and was smaller than normal. In its natural position the hilum faced anteriorly and the vessels emerging from it ran up over its upper pole. The ureter was short and tortuous, and its diameter was increased by comparison with its fellow. The renal artery was single and arose from the bifurcation of the aorta in precisely the situation one would expect to find the middle sacral artery. This vessel was absent. The left renal vein flowed into the right common iliac vein just distal to the point where the two common iliac veins unite to form the inferior vena cava (*Fig.* 170). The

kidney was dark purple in colour, due to strangulation of its blood-supply, and on histological examination it was found to be intensely congested with multiple hæmorrhages throughout its substance. An interesting feature was that in the pelvic kidney all changes from slight thickening of the glomerular capsules to advanced fibrosis and hyalinization of the glomeruli were noted. The causation of these changes is uncertain but they may perhaps have been due to defective blood-supply, as corresponding changes were not found in the normally placed right kidney. It is clear, therefore, that the pelvic kidney would in time have become functionally inefficient. No significant abnormalities were found in any other system.

Comment.—A search of the available literature on this subject has revealed that, with the exception of the case reported by Ransohoff (1920), no case similar to this one has yet been described. This kidney possessed a short mesentery and only one set of vessels. The presence of a mesentery and the absence of fixation rendered torsion a possibility, and it is interesting to note that in Ransohoff's case also there was only one renal artery. This, I think, is important. In most cases of pelvic ectopic kidney reported, multiple renal arteries and veins are described and these vessels frequently arise from different trunks often on both sides of the body. The factor which precipitated the torsion was probably the increased peristalsis engendered by the diarrhœa.

Many other congenital defects have been described in association with renal ectopy. These defects, as would be expected, mainly affect some other part of the genito-urinary system and may appear as absence or deformity of the pelvic viscera or external genitalia. Guizzetti (1918) states that anomalies of the genitalia are present in one-third of the cases of congenital renal abnormality. Associated defects of the bowel have been described by Looney and Dodd (1926), and in one case Thompson and Pace (1937) noted an absence of the frontal sinus. Widespread developmental defects, affecting structures embryologically unassociated, have thus been found in cases of renal ectopy. This suggests that a germinal defect of one-half of the body may be the responsible factor.

SUMMARY

1. The incidence and anatomical peculiarities of ectopic pelvic kidney are reviewed.

2. The embryological theories on the subject of this deformity are considered.

3. The pathological changes to which such a malplaced kidney is liable are discussed.

4. A case of torsion of a pelvic kidney in an infant is described.

I am indebted to Detective Sergeant Kenneth Moore, of the City of Sheffield Police Photographic Department, who was responsible for the photograph.

REFERENCES

BROWN, ALICE L. (1931), *Amer. J. Anat.*, **47**, 117.
CARLETON, ALICE (1937), *J. Anat.*, **71**, 292.
DE, M. N., and SINHA, S. C. (1934), *Ibid.*, **68**, 357.
GILMAN, M. B. (1927), *Anat. Rec.*, **36**, 149.
GRUENWALD, P. (1939), *Ibid.*, **75**, 237.
GUIZZETTI, P. (1918), Abstr. *J. Amer. med. Ass.*, **71**, 1867.
GUTIERREZ, R. (1936), *J. Amer. med. Ass.*, **106**, 183.
HERMAN, L. (1938), *The Practice of Urology*, 170. New York: W. B. Saunders Co.
LOONEY, W. W., and DODD, D. L. (1926), *Ann. Surg.*, **84**, 522.
LUCAS, C. (1934), *J. Anat.*, **68**, 270.
PAN, N. (1924), *Ibid.*, **58**, 271.
RANSOHOFF, J. L. (1920), *Surg. Gynec. Obstet.*, **30**, 356.
SHORE, L. R. (1930), *J. Anat.*, **64**, 344.
SMITH, S., and BOULGAKOW, B. (1925), *Ibid.*, **59**, 188.
STEWART, M. J., and LODGE, S. D. (1923), *Brit. J. Surg.*, **11**, 27.
THOMAS, G. J., and BARTON, J. C. (1936), *J. Amer. med. Ass.*, **106**, 197.
THOMPSON, G. J., and PACE, J. M. (1937), *Surg. Gynec. Obstet.*, **64**, 935.
THOMPSON, R. (1914), *J. Anat.*, **48**, 280.

TORSION OF THE GREAT OMENTUM

REPORT OF FOUR CASES

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INTRA-ABDOMINAL torsion of the omentum is not common as reviewed in the literature. It is certain, however, that many cases have not been reported. The variety of torsion of the whole great omentum in the absence of any hernial history or discoverable intra-abdominal causative lesion is rare. Of this primary, idiopathic, or simple type, up to December, 1944, there are now recorded about 73 cases including 1 case of my own. The remaining 3 personal cases are also examples of abdominal torsion of the whole omentum, of the secondary class, i.e., two were bipolar with a pelvic adhesion and the last case swollen and infected by tubercle bacilli. Marchette (1851) and Oberst (1882) are credited with the reports of the first 2 cases of secondary torsion, hernia being present in each case. Eitel (1899) noted the first case of primary torsion. Rudolph (1903) is the only one previously credited with 4 cases. My four specimens are illustrated in *Figs.* 171–4. Most surgeons of experience must have come across omental (other than great omentum) and epiploic tags adherent and torsioned: I have seen 2 such cases, 1 being in connexion with the gastro-hepatic omentum. Such cases are not discussed here.

The great omentum may twist as a whole, or as a part or strand: either may be complete (strangulated) or incomplete (congested); either may be primary or secondary. Primary twists are necessarily intra-abdominal and unipolar and no definite

cause can be assigned. Secondary rotation cases may be uni- or bi-polar, a hernia, adhesion, cause for omental deformity, or evidence of past or present intra-peritoneal inflammation being present; the omentum may be entirely intra-abdominal, wholly in a hernial sac, or there may be combined hernial and abdominal rotation. The condition may be acute or subacute, and there are probably recurrent cases.

Of all varieties some 190 cases are recorded in the literature.

CAUSATION

Though still speculative, it must be clear that a combination of factors are responsible: some predisposing, such as peristaltic pushes by the muscle of the intestines, abdominal wall, and diaphragm; sudden jerky body actions and rotations; direct blows; omental disfigurement by tumours, overloading, or uneven fat distribution, pedicle formation, scarring, raggedness, adhesions, and bi-polar attachments; displacement of the omentum during operation or by abdominal tumours. A history of all such cases is found among the cases recorded. A partial twist having started and caused congestion of the veins with œdema, it has been suggested (Payr) that the shorter and firmer arteries may complete the omental writhing. Any other condition producing œdema of the omentum, e.g., the heart or adjacent peritoneal inflammation, might produce the same result. *Case* 1 of my series followed almost immediately after the cranking of a motor car. *Case* 2 had a severe jolt the day before onset, had a right inguinal hernia (empty sac), and a bi-polar torsion. *Case* 3 had a failing heart from severe untreated thyrotoxicosis, a hernial operation scar, and bi-polar torsion. In *Case* 4 tuberculous inflammation of a the great omentum was present. If it is comprehensible that a bi-polar or peg-top torsion can take place in its smooth-lined cavity by any or a combination of the above factors, then one must assume that the same conditions play their part in the hitherto difficult aetiology of idiopathic torsions. It is not difficult to imagine how a hernial ring with entering omentum will lead to secondary axial rotation: Is not the same condition present, multiplied, in the crevices and potential spaces among the viscera and peritoneal folds of the packed abdominal cavity in primary torsion? Any argument suggesting that primary torsion would result more frequently appears unreasonable because such commencing torsion of an omental border or strand among smooth structures will invariably be temporary and right itself. It is, moreover, considered that such slight degrees of axial rotation may account for fugitive abdominal pain, so difficult of diagnosis. Furthermore, there is evidence that even more advanced rotation may untwist spontaneously. Observation of the great omentum during routine operations shows its great mobility, its wanderings, variable size, raggedness, surface irregularities due to fibrosis, and uneven distribution of fat. The heavy, long, and distally wide omentum appears the more susceptible to torsion, judging by my cases and the majority of the reports. It has been well said that mobility is imparted by postures and peristalsis, pulsations, and pulls, percussions and punches—to which may be added pinches, pouches, and plastics. Much interest and speculation has been shown in the aetiology of axial rotation of tissues, and it is apparent that more than one factor is responsible in torsion of the whole great omentum.

SEX AND AGE

Males are more often affected than females, an incidence which may be accounted for by trauma or exertion. In the primary cases 42, or 59 per cent, were males, and 29, or 40 per cent, females. The largest numbers of cases fall in the age group 30–55 years (65 per cent), very uncommon at the extremes of age. The youngest were aged 5, 7, 7, 12, and 21 years; 2 cases aged 63 were in the idiopathic group. Among secondary cases the ages of 1 and 3 years are mentioned, but the age grouping is very similar to the above.

CASE REPORTS

Case 1.—W. L., male, aged 50. No previous abdominal history; not obese. Sudden pain in epigastrium Dec. 8, 1926, after winding starter of car. Worked that day with discomfort. Next day condition the same; stayed at home. On Dec. 10, examined; complained of lower right-sided pain and soreness. T. 99·6°, P. 100. Felt sick. No vomit. Tenderness and slight rigidity rather high for an appendix. No inguinal hernia.

Fig. 171.—*Case* 1. The twisted omentum. (*Actual size.*)

Later that night, T. 102°. Dec. 11, morning, T. normal, P. 100. Very tender, hurts to move in bed. Indefinite swelling present high in right iliac fossa. Diagnosis (?) appendix abscess. Operation same morning: Appendix normal. Sero-sanguineous fluid in abdomen. Mass consisting of the whole great omentum acutely torsioned and purple, with no adhesions (*Fig.* 171). Lower extremity narrow and pedicled, 3–4 anti-clockwise rotations. Recovery. A case of acute, primary, intra-abdominal torsion of the whole great omentum.

Case 2.—W. L., male, aged 57. Right inguinal hernia with empty sac. July 5, 1939, gradual onset of abdominal discomfort and pain in right abdomen settling in lower right quadrant. Patient considered it was due

to a fall the day before. Admitted July 6 at 10 a.m. complaining of abdominal pain and soreness, nagging and not severe. During the night there was frequency and pain during micturition. T. 99·2°. Tender in right iliac fossa. Diagnosis ? appendicitis. No nausea or vomiting. Seen again at 1 p.m. and operated. A long, heavy, deeply congested, fat great omentum, located in the midline, completely torsioned 2½ turns clockwise, tightened by a firm old-pointed fibrous adhesion to the posterior wall of the bladder, was removed (*Fig.* 172).

Fig. 172.—*Case* 2. The specimen. (×¼.)

Appendicectomy. Sero-sanguineous fluid in abdomen; much œdema of tissues, especially near the transverse colon attachment, which was devoid of fat. This thinned-out omental upper border had formed the pedicle and immediately below it was a rounded firm mass of fat suggestive of a lipoma in the omentum. Recovery. A case of acute, secondary, intra-abdominal, bipolar torsion of the whole omentum. The fibrous firm-pointed adherent end of this peg-top omentum had almost certainly acquired its inflammation in the past from entry and exit into the right inguinal sac.

Case 3.—W. I. S., male, aged 38. An untreated acutely thyrotoxic patient with a pulse of 130 on admission. Scar of repaired right inguinal hernia present. Twelve hours before operation he was seen by his doctor at night with severe right upper abdominal and epigastric pain and vomiting, and thought to be gall-bladder. Admission Sept. 24, 1941. Large pulsating thyroid, exophthalmos. P. 130, T. 100°. Rigid and groaning in pain (? exaggerated). Tender whole of right side of abdomen. Tentative diagnosis: perforated duodenal ulcer. At operation a well-loaded completely torsioned whole great omentum adherent by fibrous strands to the pelvic floor, showing no obvious signs of gangrene, was untwisted and the abdomen closed hurriedly. A fair amount of clear pinkish-yellow fluid was contained in

Fig. 173.—*Case* 3. The specimen. (*Actual size.*)

the abdomen. The patient died a few hours later. The omentum was recovered post mortem the same day and was found untwisted but easily adjusted back into the rotated position seen at operation. The lower pole was firm and bound together by fibrosis and may easily have become inflamed by entering his hernial sac in the past (*Fig.* 173). A case of acute, secondary, intra-abdominal, bipolar torsion of the whole omentum with some œdema due to severe thyrotoxicosis.

Case 4.—W. H., female, aged 17. No hernia. Admission on April 12, 1944, with a history of acute sudden abdominal pain six days previously. Vomited once. The pain and discomfort varied, but seemed better for three days. Tongue clean. T. 99·2°. Tenderness over lower abdomen, right more than left. Rigidity very slight. Diagnosis ? appendicitis, much doubt. Not in much pain. On April 13, T. 102°. Operation decided ? appendicitis. Pain worse. A very massive congested omentum, swollen, bright scarlet

in patches, was found rotated 1 turn anti-clockwise. Much pink fluid in abdomen and much œdema between the layers at the colon attachment. It was untwisted and the vessels palpated. The extreme right edge vessels alone appeared pulseless. About one-fifth of this massive broad, long omentum was removed (*Fig.* 174). The

Fig. 174.—*Case* 4. Portion of omentum removed at operation. (× ½.)

intestines and appendix were healthy. Search was made for an intra-abdominal disease, but none found. Investigation and sections of the removed omentum revealed the presence of giant cells and tubercle bacilli. Recovery. A case of acute, secondary, unipolar, intra-abdominal torsion, incomplete; previous œdema due to a tuberculous infection.

DIAGNOSIS

The condition is rarely diagnosed or even suspected. I am therefore not too ashamed to admit my omission even with experience of four cases. A mention of omental torsion, without conviction, in the second case while under anæsthesia, is the nearest I got to a diagnosis. A great number of abdominal states, from inflammations to tumours, have been selected in error: Over 80 per cent, however, are considered as appendicitis; a much smaller number as perforated ulcers or cholecystitis. Barely a half-dozen are reported correctly diagnosed. From my experience and the result of studying the histories of numerous reported cases, the following points are worthy of notice and should lead to a diagnosis on occasions. The patient, probably aged 20 to 55 years and a male, gives a right-sided abdominal history of pain which gradually gets worse, is often in spasms, and is usually relieved by lying down. Nausea, vomiting, pyrexia, pulse-rate, distension, a white count, a furred tongue, and toxic state are usually conspicuous by their negative value; if positive, are anything but marked features. The patient after admission and in bed nearly always appears well and placid. Tenderness and rigidity on careful palpation again are not impressive. The picture, typically, is one of abdominal pain, gradually getting worse; it reaches the third day, obviously a case for surgical inquiry, with a lower right quadrant tenderness and little else to show for what ought to be a more advanced abdominal state. There may be a history of undue exertion or accident and a hernial scar or sac may be present. An appendix is suspected and yet one feels inclined to hold one's hand. The palpation of a doughy tumour in the mid-line or to the right, often above the appendix area is a valuable suggestive sign. It must be realized that a rotated omentum varies much in size and the position occupied. In all my four cases the tumour at operation was either in the midline or to the right. The position in bi-polar torsion will obviously be influenced by the site of the lower adhesion. It was the palpation of the tumour in my second case, under anæsthesia, that led to the mention of omental torsion.

Three of my cases were thought to be appendicitis, were doubted, and were not operated on immediately. The fourth was considered an emergency as a perforated ulcer; his agony and rigidity were obviously greatly exaggerated by his nervous thyrotoxic state and led me astray. The prognosis is good in omental torsion. Apart from complications, remote, few have succumbed to the abdominal condition.

OPERATION

The procedure, as in all cases of torsion, is obvious. The earlier the exploration the fewer the regrets. In such doubtful diagnoses the gridiron incision should not be used. The omentum or a part is almost always removed. In *Case* 3, for reasons given, I untwisted what was probably an unstrangulated omentum for speed, the patient dying from thyrotoxic effects in a few hours. In *Case* 4 I believe I was justified in not embarking on the removal of the whole of a huge omentum, though I did not know at operation that it was infected by early tuberculosis. The patient recovered. Thus one case died out of four, and this an omentum which was least affected by strangulation judging by its colour—death was due to thyrotoxic cardiac failure, and in the absence of this complication he would have survived.

The description of the rotated omentum removed, has often been discussed and need not be repeated. It should, however, be examined with care and a note made of any tumour, pedicle formation, fibrosis, or deformity present. The maximum narrowing or pedicle formation has been noted in all parts of the specimens removed. *Cases* 1 and 2 were constricted above near the colon. *Case* 3 had a narrowing 3 in. from the lower end just above the consolidation. In *Case* 4 no narrowing was present. *Case* 2 was an excellent example of a peg top, the adhesion below being firm, thick, and pointed. There may be few or numerous twists, clockwise or anti-clockwise.

SUMMARY

1. An account has been given of intra-abdominal torsion of the great omentum, after a survey of the literature.

2. The diagnosis and aetiology have been discussed.

3. Four personal cases have been presented.

4. The specimens are illustrated. They were shown at the Section of Surgery, Royal Society of Medicine, on Dec. 6, 1944, and have been accepted by the Royal College of Surgeons' Museum, London. They represent intra-abdominal axial rotation of the whole omentum, *Case* 1 being a primary, *Cases* 2–4 secondary torsions.

5. Among the collection labelled omental torsion, too many cases are being recorded of twists of a small gastro-colic strip or tag. A separate group should include the more important torsion of the whole great omentum.

6. An extensive and critical survey of all cases and previous reports up to 1944, brings the total cases to about 190, of which 73 (38 per cent) are idiopathic.

For good reasons I have excluded the following from the primary group: Eitel; Noble; Simon; Fuller; D'Allaines and Ruffiac; Reid. Each one at times has been included by some authors and discarded by others.

All hernial cases have been excluded and many errors found and corrected in the literature, in bringing the number of cases up to date.

Since going to press, Rear-Admiral Cecil P. G. Wakeley in a personal communication has kindly informed me that he has now dealt with three cases of omental torsion. Two of these cases were published in the *Medical Press and Circular*, 1929, Jan. 9.

BIBLIOGRAPHY

ADAMS (1923), *Boston med. surg. J.*, **180**, 981.
ALECHA and LANZA (1942), *Rev. Cirug. B. Aires*, **21**, 538.
ALLEN, L., (1933), *New Engl. J. Med.*, **209**, 253.
ANDERSON, E. L. (1931), *J. Amer. med. Ass.* **96**, 1227.
AIMES (1919), *Progr. méd., Paris*, **393**, 425.
BARSKY, E. K., and SCHWARTZ, A. M. (1937), *Amer. J. Surg.*, **38**, 356.
BASH, F., and BEAUX, A. (1942), *Prensa méd. argent.*, **29**, 433.
BENTON, J., and GARRY, M. (1934), *Wis. med. J.*, **33**, 204.
BERGQUIST, G. (1936), *Acta chir. scand.*, **78**, 322 (quoted by LIPSETT).
BLACK, J. M. (1929), *Brit. med. J.*, **2**, 458.
BRILL, L. (1933), *Ibid.*, **1**, 784.
BROWN, F. R. (1926), *Ibid.*, **1**, 183.
BULMAN, M. W. (1924), *Ibid.*, **2**, 116.
CHANDLER, E. B. (1928), *Canad. med. Ass. J.*, 18, 579.
COEN, V. (1928), *Policlinic*, **35**, 252.
COWELL, F. (1924), *Brit. J. Surg.*, **12**, 738.
CORNER, E. M., and PINCHES, H. (1905), *Amer. J. med. Sci.*, **113**, 314.
CROMIE, D. (1935), *Brit. med. J.*, **1**, 106.
D'ERRICO, E. (1930), *New Eng. J. Med.*, **203**, 1181.
EITEL, quoted by various authors.
FAGGE, C. H. (1928), *Lancet*, **2**, 1167.
FARR, C. E., and BACHMANN, R. F. (1933), *Ann. Surg.*, **97**, 766.
FOSTER P. S. (1928), *Brit. J. Surg.*, **15**, 522.
GALLOWAY, W. D. (1935), *Brit. med. J.*, **2**, 899.
GIORDANA, F. P. (1942), *Prensa méd. argent.*, **29**, 2014.
GROVES, W. R. (1925), *Med. J. Aust.*, **2** 607.
HEDERSTAD, C. G. (1939), *Ann. Surg.*, **109**, 57.
HEDLEY (1911), *Brit. med. J.*, **1**, 1246.
HERBERT, G. (1935), *St. Barts Hosp. J.*, Oct.
JEFFERIES, J. W. (1931), *Ann. Surg.*, **93**, 761.
LAWRENCE (1925), *Sth. med. J., Nashville*, **18**, 423.
LIPSETT, P. J. (1941), *Ann. Surg.*, **114**, 1026.
LUCCA, E. (1935), *Arch. ital. Chir.*, Feb., 388.
MACAULEY, C. (1928), *Brit. J. Surg.*, **15**, 387.
MCWHORTER, G. L. (1928), *Arch. Surg.*, **16**, 595.
MANSON, J. S. (1937), *Brit. med. J.*, **2**, 968.
MARTIN, J. D. (1941), *Sth. Surg.*, March 10.
MORRIS, J. H. (1932), *Arch. Surg.*, **24**, 40.
NIEMEIER, O. W. (1935), *Canad. med. Ass. J.*, **32**, 175.
NOBLE, T. B. (1904), *Amer. J. Obstet. Gynec.*, **49**, 364.
OGHI, A. (1942), *Prensa méd. argent.*, **29**, 1971.
POLLIDARI, A. (1927), *Arch. ital. Chir.*, **17**, 453.
REID, G. A. (1928), *Brit. J. Surg.*, **15**, 523.
RENY, M. (1933), *Bull. Soc. nat. Chir.*, July 15, 1115.
RIDDELL, J. (1926), *Brit. med. J.*, **2**, 525.
ROBB, D. (1930), *Lancet*, **2**, 1347.
ROBERTSON, J. H. (1934), *Trans. roy. Med.-chir. Soc., Glasgow*, **28**, 72.
ROCHELLE (1933), *Amer. J. Surg.*, **20**, 97.
RONALD, A. (1929), *Brit. med. J.*, **1**, 811.
SALSBURY, C. R. (1935), *Brit. J. Surg.*, **23**, 115.
SMYTHE, M. J. (1930), *Lancet*, **2**, 572.
STEWART, W. (1928), *Brit. med. J.*, **2**, 701.
STEINKEL, C. R. (1941), *Ohio State med. J.*, **37**, 959.
SUSMAN, M. P. (1928), *Med. J. Aust.*, **2**, 756.
TELLER, F., and BASKIN, L. F. (1938), *Amer. J. Surg.*, **39**, 151.
THOREK, M. (1931), *Med. Jour. Rec.*, **133**, 526.
WALLACE, H., and MILLER, R. H. (1933), *New Eng. J Med.*, **208**, 831.

PHYSIOLOGICAL GASTRECTOMY

THE OPERATION OF LIGATURE OF THE ARTERIES OF THE STOMACH TO RELIEVE HYPERACIDITY AND TO PREVENT RECURRENT ULCERATION AFTER GASTRO-ENTEROSTOMY

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DUE largely to dietetic errors and to deficiency in vitamins, the incidence of duodenal ulcer in South India is extremely high. Thus at the hospital where I have been working for the last twenty-two years, a very large number of operations have been done for this condition, and an unrivalled opportunity has been offered for clinical research as to the after-effects of various methods of treatment.

During the twenty-year period, 1924–1944, some 5000 operations for duodenal ulcer were done at Neyyoor, and 1500 at the branch hospital at Kundara, attached to Neyyoor and run (with many other branches) in conjunction with it. The majority of these cases have been analysed and recorded in the JOURNAL (Somervell, 1936 and 1941).

In the latter of these two papers I noted that I had been replacing the extensive operation of partial gastrectomy after the method of Finsterer by the more modest procedure of ligating the arterial supply of the stomach, with good immediate results

in the cutting down of hyperacidity, and therefore probably in the prevention of recurrent (gastro-jejunal) ulceration. At the time of writing the paper in question these cases had not been observed for long, and in fact the operation of vascular ligature had not been done in more than 150 cases. I and my colleagues have now done the operation in nearly 400 cases, of which over 160 cases have had a test-meal done both before and three weeks after operation, and 82 cases have had a late follow-up, including the performance of a fractional test-meal and a thorough clinical examination. It is now nearly eight years since I started doing this operation, and I feel it would be wrong to let more time elapse in reporting the late results of these cases, for in the opinion of my fellow-workers in India, as well as of myself, it has established itself as the treatment of choice in all cases of duodenal ulcer which have been suffering for more than a year and show marked hyperacidity to test-meal examination.

Partial gastrectomy, as we know, cuts down the acidity of the stomach to a remarkable extent, but even in the most skilful hands it is an operation which carries with it a degree of risk, the mortality being in the neighbourhood of 4 per cent. In over 380 cases of arterial ligature with or without gastro-enterostomy done by me and my colleagues, I can trace only 1 death. On this minimum operative risk, as well as its satisfactory late results, I feel that the simpler operation rests its claim to superiority.

In my former paper I described only one method of doing the operation of gastric ligature; but since then various other techniques have been employed, and they, too, have now been examined in the light of both early and late results.

The value of the fractional test-meal in these observations is open to question. It is, with radiography, the only really objective method of assessing results, though nobody knows better than the writer how limited it is in many ways. What we are aiming at is a completely healthy patient, free from pain, able to eat anything, and to live a normal life. He must also continue his health, and not develop any recurrent ulceration of the stoma or of any part of the upper alimentary tract. This much can be ascertained by a full clinical examination. But in comparing methods of technique and alternative operations the test-meal provides an objective and numerical criterion, and, if it is carefully done, with no possibility of the Ryle's tube having reached the duodenum or gone through the stoma, it gives an accurate picture of the acidity of the stomach before and during the taking of a standard meal, which is of real value for purposes of comparison. There is no doubt that hyperacidity is one of the major factors in the aetiology of duodenal ulcer. Among the people of Travancore, where all the work on which this paper is based has been done, duodenal ulcer is extremely common and the average acidity of the population is high. Those patients among our large series who have developed gastrojejunal ulcer have been those with the highest acidity. Of all complications which are likely to follow gastro-enterostomy, recurrent ulceration is the most serious. Therefore it seems reasonable to take the test-meal results as a fair test of the efficacy of a gastric operation, and of its likelihood to be followed by serious trouble.

In the Neyyoor Hospital every gastric case has a fractional test-meal done as a routine procedure, and in deciding on what treatment to adopt, and more particularly what operation to do, in each individual case, I have always allowed the test-meal result to have great influence on the decision. In a case with normal or only slightly increased acidity, and a fasting juice with a total acidity under 60, I consider gastro-jejunostomy to be a sufficient operation—that is, if operation is reckoned to be the treatment of choice for the case. In all cases where the fasting juice is above 60, and especially in those where it continues to be at a high level, the operation has taken the form of gastro-jejunostomy combined with the ligature of the arterial supply of the stomach, as described below. This has now, in my practice, entirely replaced the more formidable gastrectomy, except in cases where there is a gastric ulcer as well as the duodenal one, or there is some suspicion of malignancy.

THE TECHNIQUE OF THE VARIOUS METHODS OF GASTRO-VASCULAR LIGATURE

Blood-supply of the Stomach.—The stomach is supplied by the following vessels, as far as its acid-secreting portion is concerned—this portion is, of course, the body of the stomach; for at the pyloric end, as well as in the fundus near the cardiac end, there is little or no secretion of acid (Babkin, 1944):—

Left gastric artery: Supplies the lesser curvature in its upper three-quarters.

Splenic artery (by way of the vasa brevia and left gastro-epiploic): Supplies the posterior part of the body of the stomach, and upper third of the greater curvature.

Right gastro-epiploic: Supplies the lower two-thirds of the body, and of the greater curvature, and part of the pyloric antrum.

Right gastric (from hepatic artery, or proximal portion of gastro-duodenal artery): Supplies the lower quarter of the lesser curvature and the upper part of the pyloric antrum.

From these vessels the actual blood-supply of the stomach is by means of short branches at frequent intervals, most of them being about half an inch apart. The upper part of the lesser curve is, however, supplied by a sheaf of vessels running along the front of the stomach wall close to this curvature and dividing into numerous small branches near the incisura.

Standard Operation.—The operation of tying the arteries consists in its simplest form—i.e., that which is easiest to do—of firmly ligating, by means of under-running them with a curved needle threaded with fine silk, about five out of every six of the small branches which run from the gastro-epiploic artery to the stomach wall (*Fig.* 175). These are tied as far up the greater curvature as can be reached without pulling at the stomach, using the ordinary paramedian incision commonly employed in the operation of gastro-enterostomy. The sheaf of vessels on the lesser curve is ligated *in toto*. The arteries at the pylorus and within an inch of it need not be tied. A hole is made in the mesocolon, as is usually done for a gastro-enterostomy, and the back

of the stomach is inspected. It will be found that some of the arteries along the greater curve have already been tied, but some more will require ligating to bring the number of arteries tied up to approximately five-sixths of the total number. The stomach is gently pulled farther through the mesocolon, and all the arteries that can be reached without undue strain are tied. Unless the patient is under spinal anæsthesia, great care must be taken not to pull at the stomach too strongly. The utmost gentleness must be used throughout: this can be done if the

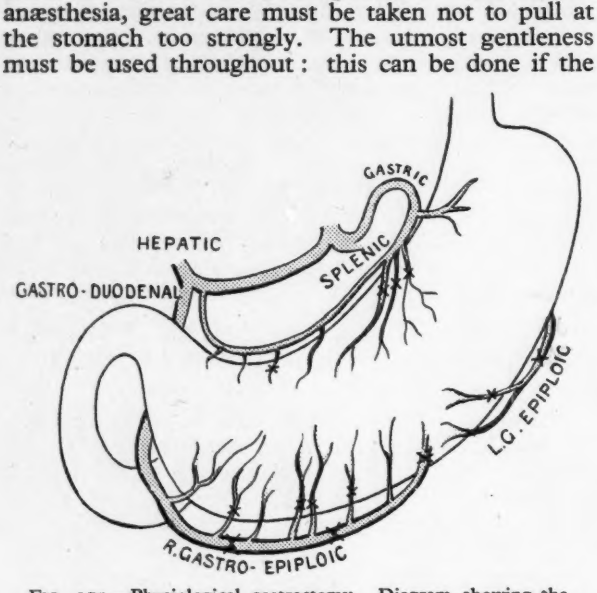

FIG. 175.—Physiological gastrectomy. Diagram showing the arteries tied on the anterior surface of a typical stomach.

incision is adequate, and the wound well retracted as required. Too great a pull on retractors makes for a painful wound: too great a pull on the stomach makes for the much more serious splanchnic shock.

The whole procedure of tying the arteries as described takes about ten minutes or rather less. Gastro-jejunostomy is then performed in such a way as to make the opening in the stomach vertical in direction when the stomach is returned to the abdomen, with its distal end close to the greater curvature. If this is done there will be no tendency to kink the jejunum just below the anastomosis.

The mesocolon is then sewn to the wall of the stomach in such a way that the cut edges are at least an inch away from the anastomosis on all sides, especial care being taken to fasten the anterior end of the hole in the mesocolon firmly to the stomach wall 1 or 2 in. anterior to the anastomosis, to avoid any likelihood of the slipping of the mesocolon over the jejunum and kinking it.

When the arteries are tied in this way the usual effect is an immediate and considerable drop in the acidity of the stomach. A hyperacid stomach becomes one which secretes less than the normal amount of acid. Free HCl is often cut down to *nil* throughout the two or three hours during which the test is done.

Now and then a case is met with in which this operation has no effect at all in cutting down acidity. This must be so, either because an insufficient number of arteries has been tied, or else because with the arteries the veins have, of course, been tied. Every surgeon knows that if a main artery to a limb has to be tied, gangrene is less likely to develop if the vein is also ligated. Similarly, if we wish to deprive a certain portion of the stomach of its blood-supply in order to stop the secretion of acid, it will be more effectively done if the arteries alone, without their veins, are tied.

Modified Procedure.—In order to do this, another technique was devised, and a series of cases was done in which the arterial supply only of the stomach was dealt with. The four main arteries to the stomach were tied near their origins from the larger vessels, in such a way as not to interfere at all with the return of venous blood from the stomach. In a third series, these four main vessels were tied, with additional ligature of 4 out of every 5 of the smaller branches going to the wall of the stomach itself. The early and later results from these two series of cases were not in any material way different from those obtained by the simpler method outlined above, which we have adopted as the standard method of operation. The reduction in acidity obtained by these three methods is almost exactly the same, and there is therefore no need to perform the more elaborate and more difficult operations, which necessitate considerably more handling of the stomach than is required in the simplest of the three.

RESULTS

The whole series of cases was also divided into age-groups, those under 30 years and over 40 years of age respectively showing very similar results with one another and with the general series of all cases in which arterial ligature was done.

In a few cases of marked hyperacidity, with symptoms of duodenal ulcer, no ulcer was found at operation. In view, however, of the very high acidity, and as a means also of testing the effect of arterial ligature without gastro-enterostomy, the arteries were tied in this series of 6 cases. Their results are identical with those obtained from the cases in which gastro-jejunostomy was combined with the arterial ligature. This shows that the effect of the operation in lowering acidity is entirely due to the ligature of the arteries, and not to the gastro-enterostomy.

Together with the results of the operations mentioned above, a series of duodenal ulcer cases treated by gastrojejunostomy alone without arterial ligature is divided into two portions, those with high and low acidity respectively before operation. These act also as controls whereby to test the efficacy of the operation of arterial ligature.

In all the cases analysed in this paper, the following tests were done and were recorded as protocols. From them averages were worked out, which are herein tabulated, to save the reader from long lists of figures.

1. Fractional test-meal before operation. Figures recorded here are (*a*) the total acidity of the fasting juice, and (*b*) the average of the other readings of total acidity, neglecting the fasting juice and the second reading, which represents the acidity so soon after the ingestion of the meal of gruel as to be valueless for purposes of comparison. The meal used was similar in all cases, consisting of 12 oz. of rice gruel ('conjee').

2. Fractional test-meal before discharge from hospital, i.e., about 17 to 20 days after operation.

3. Fractional test-meal at a later date, varying from 6 months to 6 years after operation.

This third series of test-meals was obtained by the only method of follow-up which is likely to be effective in rural India. Every patient concerned was written to, and asked to come and see me at one of several centres, which I visited with a staff of male nurses and a pathologist, stating the dates of my visits at the various centres on the list sent to every patient. Unfortunately this follow-up had to be done in war-time, when transport difficulties were great: but in spite of this some 82 cases of arterial ligature, and 8 cases who had had gastrectomy, as well as 40 cases whose operation had been gastrojejunostomy alone, turned up for the examination.

The results of the test-meal examinations done are summarized in the form of averages in the accompanying table, under the various headings mentioned above.

Discussion of Results (*Fig.* 176).—

1. Regarding the series tabulated, in which arterial ligature was done as well as gastro-enterostomy, it was known by the results reported in 1941 that the effect of this operation is to cut down acidity to normal levels as evidenced by the test-meals done shortly after the operation. But it was not known to what extent this reduction of acidity persisted. Only 10 cases had been tested a year after operation, and these showed that for this period at any rate reduction of acidity actually increased. Now, however, it is found that this lowering of acidity persists for at least five years, and the late results of a much larger series of cases show very satisfactory figures both for the acidity of the fasting juice, and for the average total acidity during the two hours or so after the meal is given. With regard to the incidence of recurrent (gastro-jejunal) ulcer, from the total number of cases, nearly 400, in which I and my colleagues have done this operation, only 1 has returned to our hospital at Neyyoor with a gastrojejunal ulcer. From the last 300 gastrectomy cases done during the same period, a total of 7 have returned with recurrent ulceration. While in the rural districts of South India accurate and complete follow-up is impossible, it can at least be said that it is very unlikely that there are 6 other cases which have developed ulcers after arterial ligature, and not come to us, while there are none among the gastrectomy cases which have developed ulcers at all. It is therefore almost certain that the operation of arterial ligature offers to the patient a surer safeguard against the serious complication of recurrent ulceration than does any other surgical procedure.

TABLE I.—RESULTS

No.	Operation	Before Operation		Three Weeks after Operation		Later (1–5 yr.)	
		Fasting Juice	*Average*	*Fasting Juice*	*Average*	*Fasting Juice*	*Average*
1	L.A. plus P.G.E. (82 cases)	81·7	65·3	48·0	45	40	41
2	L.A. only (14 cases)	80	62	46	39	40	44
3	L.A. plus P.G.E. Main arteries only (14 cases)	86	65	48	44	43	43
4	Gastrectomy (8 cases)	65	64	36	42	75	62
5	P.G.E. only. High acidity (29 cases)	77	74	70	55	45	47
6	P.G.E. only. Low acidity (11 cases)	47	45	50	51	60	47
7	L.A. plus P.G.E. under 30 yr. of age (26 cases)	80	65	47	44	40	44
8	L.A. plus P.G.E. over 40 yr. of age (22 cases)	75	66	49	48	43	44

Note: L.A. signifies ligature of arteries as described; P.G.E., posterior gastro-enterostomy.

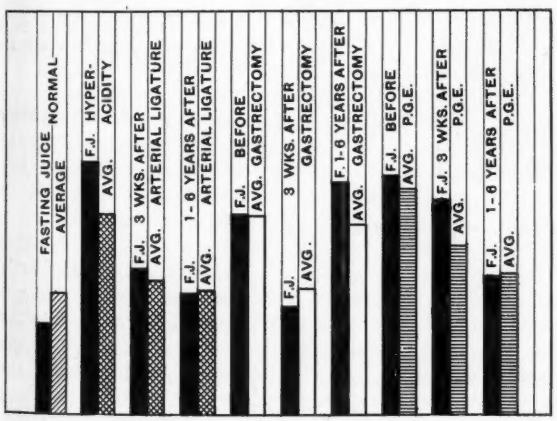

FIG. 176.—Early and late results of various operations.

2. With regard to the cases in which the operation of arterial ligature alone has been done, without gastro-enterostomy, the early and late results are exactly similar to those in which gastro-enterostomy was combined with arterial ligature. It is evident, therefore, that the reduction of acidity is caused by the ligature of the arteries, and not by the gastro-jejunostomy. This is further evidenced by a comparison with the gastro-enterostomy cases reported in Series 5 of the table.

3. This series shows that where the operative technique consisted of tying the four main arteries only, separate from their veins, the immediate and later results were almost exactly the same as those obtained by performing the simpler technique described as our standard operation. There is, therefore, no point in doing the more difficult operation of ligature of the four arteries, which, at any rate as regards the left gastric artery, involves more manipulation of the stomach than does the tying of the branches to the stomach wall asdescribed.*

4. I was very surprised when I discovered that the arterial ligature produces a much more satisfactory late result in reduction of acidity than does

* It has been reported that in one case in which a surgeon tied the left gastric artery, he produced a gangrene of the spleen with fatal results.

gastrectomy. This series of cases is only a small one, but seems to show quite definitely that after gastrectomy, which reduces acidity very markedly at first, the strength of the acid in the stomach during digestion, as well as that of the fasting juice, rises to a very high level. In only 1 case of the 8 cases in this series was the reduction in acidity continued for a long period after the operation had been done. In producing permanent reduction of acidity as well as in preventing gastrojejunal ulceration, gastrectomy is not a satisfactory operation, and in addition it is a far more serious one. Arterial ligature seems to be a far more satisfactory procedure, as well as involving negligible operative risk.

5. Gastrojejunostomy alone in highly acid cases is followed eventually by a good reduction in acidity, no doubt because in cases where the pylorus is stenosed it re-establishes the ability of the stomach to empty itself: but its effect in reducing acidity is not established for a year to eighteen months after operation.

6. The paradoxical result in these cases is difficult to explain. The ultimate rise in acidity is probably due to the fact that this series of patients all showed low acidity before operation. That is to say, there was probably an amount of gastritis in these cases sufficient to have produced some hypochlorhydria. The relief of this gastritis by operation seems to have enabled the stomach to recover its power of secreting acid. The same explanation probably holds good in the gastrectomy cases, which show on the average an increase in acidity some years after operation to a level that is higher than that of the acidity before operation.

7 and 8. The results of the two age groups are very similar. Age has therefore little or no effect on the efficacy of the operation of arterial ligature.

Partial gastrectomy, as is well known, cuts down the acidity of the gastric contents as measured by a test-meal to a remarkable extent. But the diminution of acidity is not kept up indefinitely; within a few years the acidity rises to a high level again, and in any case the operation of gastrectomy is one which bears a high rate of risk, for even in good hands the operative mortality is round about 4 per cent. The operation itself is a mere removal of secreting tissue, and is in the category of operations which may be described as mutilations, that is to say, anatomical rather than physiological in its effect. Advance in surgery often rightly consists in the substitution of a minor for a major procedure; but this is only a true advance if the new procedure is at least equally effective in both its immediate and remote effects. As will be seen, this seems to be the case here: for the great reduction of acidity which occurs after the operation of arterial ligature is maintained and even increased for a period of at least five or six years, and the incidence of recurrent ulceration is practically nil. There has been only 1 death in over 380 operation cases, and in only 1 case has a recurrent ulcer been diagnosed: a far smaller proportion than in any series of cases in which any other operation was done, either observed by myself or found in the literature of the subject.

This new operation is based on physiological principles. A brief description of these is appended.

Physiology of Gastric Acidity.—The glands or crypts of the gastric mucosa are heterocrine in nature, i.e., they contain several different types of cells. Of these the parietal cells, as has long been known, are the ones which secrete HCl.

These cells are present only in the body of the stomach, being practically absent from the cardiac and pyloric ends for a distance of some 4 and 5 cm. from these two openings. Some of the parietal cells reach the lumen of the gland, while some are distant from it, being close to the basement membrane. There are, however, small intercellular canaliculi (Plenk, 1932), through which the secretion of these outer cells reaches the gland lumen (*Fig.* 177). In addition, there are in each parietal cell intracellular canaliculi, through which, apparently, the secretion flows, and in the wall of which it is probably formed (*Fig.* 178). The nucleus of the parietal cell is central, and not, as in most other gastric cells, peripheral. There are few granules, and these are not altered in number during secretion.

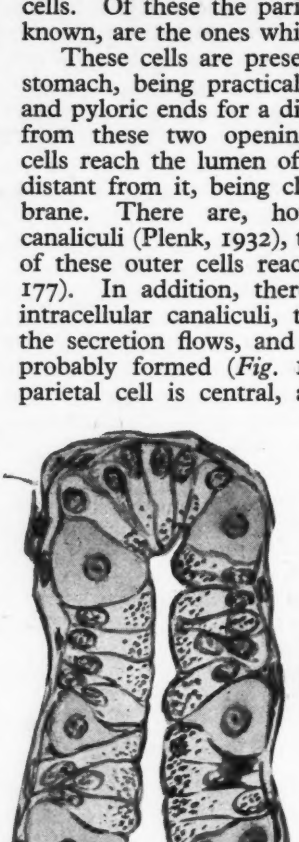

FIG. 177.—Gastric tubule. (*After Plenk*).

The parietal cells and their function are very intimately bound up with the vascular system. In the regions where they are fewest, the blood-supply of the stomach is not so rich as in other parts, and the capillaries are smallest (Hofmann and Nather, 1921). Moreover, there is an intimate correspondence between the physical chemistry of the blood and the gastric secretion. The osmotic pressure of the blood and of the gastric juice are always identical (Gillman and Cowgill, 1933). Artificial variations in the osmotic pressure of the blood are immediately followed by similar variations in that of the gastric juice. Moreover, the total chloride content of the gastric juice is always equal to the ionic content (total) of the blood. Variations in blood electrolytes are similarly followed by corresponding variations in gastric chlorine. Gillman maintains that chlorine is filtered from the blood by the outer membrane of the parietal cell, which is permeable to chlorine and hydrogen in ionic form; that HCl is secreted by the parietal cells in a diluted condition, of *p*H 6·7, and the water from it is absorbed by the cells lining the lumen of the gland, until osmotic equilibrium with the blood is established. The Cl ion, once it

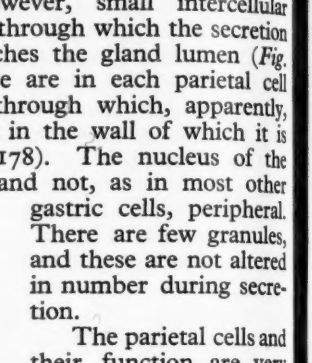

FIG. 178.—Capillaries in a parietal cell. (Bensley's copper-hæmatoxylin.)

is secreted, is unable to return to the blood-stream, as these cells are impermeable to it. After concentration, the *p*H rises to the neighbourhood of 1·0. Bensley and Hoerr (1936) consider that the parietal cells secrete a precursor of HCl in the form of a protein hydrochloride, which is later hydrolysed to form HCl. But no protein as such is excreted by the parietal cells, the secretion of which is negative to Millon's and other protein tests.

Hollander (1943) considers that the low acidity found in the parietal cells is due to the fact that the actual secretion of the HCl is done in the wall itself of the canaliculus, in which situation chlorine is found at its maximum (Collip, 1920). The residual alkali in the cell due to the escape of H ions is neutralized by intracellular buffers, and goes, with water, through the basement membrane.

From the series of test-meal results quoted in this paper, it is evident that a decrease in the blood-supply of the stomach at once causes a great decrease in the acidity of the gastric juice, both fasting juice and the juice secreted during digestion being equally profoundly affected in hyper-acid cases, and usually being brought down to almost exactly the normal for a healthy stomach.

Is it possible either to explain this effect by the generally accepted theories of the physiology of secretion of the gastric juice, or to use these observations further to extend our knowledge of these processes?

There are two ways in which the effect may be produced. A hyperacid stomach may owe its excess of acidity to an overaction of the parietal cells, in response to a chronic irritation; or to an overaction of the cells lining the lumen of the gland, from a similar cause, which results in their absorbing water from the dilute acid in excess, leaving the juice in the end with a high concentration of HCl.

The effect of depriving the gastric mucosa of a large proportion of its blood-supply may therefore be either to cause the parietal cells to secrete less acid, and possibly to cause many of these cells to die: or, on the other hand, to limit the reabsorption of water on the part of the cells lining the crypts.

It would be extremely interesting to take a section of a piece of the mucosa from the stomach of a patient who had had the operation of arterial ligature some time before, and in whom a marked reduction of acidity had taken place. Unfortunately, in the one patient of our whole series who re-submitted himself for operation for recurrent ulceration, there had been no appreciable reduction in acidity, owing, no doubt, to an insufficient number of arteries having been tied. Thus, we will have to await another case of recurrence, which seems unlikely to come our way for some time. In the meantime I am doing some experimental work, which I hope will lead eventually to the obtaining of the information we require. Histological changes will be looked for, and an investigation made to ascertain whether there is a material change in the total secretion in quantity as well as in quality. These will be reported later.

It has been questioned whether the effect of tying the gastric arteries produces its effect by the simultaneous interference with the nervous mechanism of gastric secretion.

The sympathetic nerves, or most of them, enter the stomach along the gastric arteries. Ligature of the arteries might, therefore, produce a stoppage of their action. But they would almost certainly regenerate rapidly, as they do after peri-arterial sympathectomy in other parts. The fact that the lowering of acidity after the operation just described is permanent in nearly every case leads one to the belief that the essential of the operation is the cutting-off of the blood-supply, and has little or nothing to do with the nerves. Moreover, the sympathetic nerves have very little influence on the secretion of acid, which is the function almost exclusively of the vagus nerves.

The course of the vagi is entirely different from that of the sympathetic nerves. The vagi cannot be affected by the operation described, although it is well known that division of both of them produces inability to secrete any hydrochloric acid.

The reason why section of the vagi was never tried by my colleagues or myself in order to diminish acidity is that the results are too uncertain. On the one hand, the section of one vagus has only a transient effect; on the other, section of both vagi would in theory produce a total cessation of acid secretion. If the nerves regenerated, this would be only temporary; if they did not, it might be permanent. In either case, it would seen that section of both vagi is undesirable. (*See* Babkin, *op. cit.*, pp. 198-264.)

In the meantime the useful and practical fact is known: that the result of the ligature operation is permanent in the vast majority of cases, at any rate for a number of years. It is therefore felt that the report of the cases on which this paper is based should not be delayed until the physiological findings are completed, for it is an operation which may be of great benefit to a wide circle of sufferers. It may, in fact, prove to be the answer to the vexed question as to what is the correct treatment (*Roy. Soc. Med.*, 1944) of duodenal ulcer with hyperacidity, in which medical treatment is so tiresome and so often unsuccessful, and in which the severe operation of gastrectomy is too risky, while the safer operation of gastro-enterostomy is apt in some 6 per cent of cases to be followed by recurrent ulcer at the anastomosis or elsewhere. It is the belief of my co-workers and myself that the operation as described does, in fact, settle this long-standing problem more satisfactorily than has hitherto been done.

SUMMARY

The operation of ligature of a large proportion of the arteries supplying the stomach is described. This operation leads to the cutting down of hyperacidity to normal levels, and sometimes below. It is hardly ever followed by recurrent ulceration, and the reduction of acidity is permanent, at least for five or six years, and in this respect is superior to that obtained by gastrectomy.

It is believed that this is the operation of choice in all cases of duodenal ulcer with marked hyperacidity, and it can easily be combined with gastro-enterostomy, without raising the mortality of that operation.

REFERENCES

BABKIN (1944), *Secretory Mechanism of Digestive Glands*. New York: Hoeber.
BENSLEY and HARVEY (1912), *Biol. Bull.*, **23**, 225.
COLLIP (1920), "On the Formation of HCl in Tubules of Vertebrate Stomach", *Univ. Toronto Library*, **35**.
DAWSON and IVY (1926), *Amer. J. Physiol.*, **76**, 158.
GILLMAN and COWGILL (1931), *Ibid.*, **99**, 172.
— — (1933), *Ibid.*, **103**, 143.
HOERR (1936), *Anat. Rec.*, **65**, 417.
HOFMANN and NATHER (1921) "Anat. der Magenarterien", *Arch. klin. Chir.*, **115**, 650
HOLLANDER (1943), *Gastroenterology*, **1**, 401.
PLENK (1932), "Der Magen" (Von Mollendorff's *Handbuch der mikr. Anat.*), **5**, 1. Berlin: J. Springer.
Discussion at Royal Society of Medicine (1944), *Proc. R. Soc. Med.*, **38**, 91.
SOMERVELL (1941), *Brit. J. Surg.*, **30**, 118.
— and ORR (1936), *Ibid.*, **24**, 227.

THORACO-ABDOMINAL WOUNDS IN WAR

BY GUY BLACKBURN, M.B.E., MAJOR, R.A.M.C.
AND A. L. D'ABREU, O.B.E., LT.-COL., R.A.M.C.

THORACO-ABDOMINAL wounds had an evil reputation in the Great War of 1914–8, and this has been maintained in the present conflict as shown by Gordon-Taylor's Bradshaw Lecture (1942) recording a mortality of 37 per cent; more recent figures (1944) of 44·5 per cent from the same author, and 51 per cent in a series of 292 cases from Normandy would appear to support that view. This present analysis is a survey of 126 cases from Forward areas and 74 from the Surgical Division of a Base hospital in Italy in 1943–4.

Of the 126 cases dealt with at Forward operating centres, one of us (G. B.) operated on 32—in a total of 1500 cases, with 81 penetrating wounds of the chest. There were 105 abdominal casualties in all and the percentage of thoraco-abdominal wounds (30·5 per cent) in these is misleading. Selection of cases for special centres, where much of the work was done, is probably the explanation of a figure differing so strikingly from the 12·7 per cent of Gordon-Taylor (1942), 12 per cent of Cuthbert Wallace (1918), and 11 per cent of Jolly (the Spanish War).

MORTALITY

Of the 126 cases, 46 died (36·5 per cent), and of the 74 cases reaching the Base only 3 proved fatal. This represents an all-in mortality-rate for thoraco-abdominal wounds of 38·9 per cent. It should be pointed out, however, that no case treated conservatively has been included in this series and there were 20 apart from the 126 which came to operation. The inclusion of these would lower the mortality-rate to 33·8 per cent, for recovery occurred in all.

TYPES OF WOUND

The distinction between thoraco-abdominal and abdomino-thoracic wounds is important, and the great majority belong to the first group—with an entry wound in the chest and foreign body or wound of exit below the diaphragm. They are clearly more favourable than the opposite type and less likely to require laparotomy. Wounds of the right side tend especially to belong to this category, and if the liver is the sole abdominal viscus injured, laparotomy need not, and indeed should not, be undertaken. Of the 126 cases cited, 65 were right-sided and 8 only had an associated hollow viscus lesion; 22 of the 65 (33·8 per cent) died. On the left side, on the other hand, 30 of 61 cases had a hollow viscus lesion and there were 24 deaths (39·3 per cent). The presence of solid as opposed to hollow viscus injury is in fact prognostically more favourable.

TYPE OF OPERATION

Strong preference for thoracotomy for a thoraco-abdominal wound is the natural inference, when the damage below the diaphragm is so often such that no operative interference is required. Trans-diaphragmatic manœuvres, moreover, are often no more difficult than intraperitoneal through a separate laparotomy incision. Splenectomy is an admirable example, and, in our view, is even easier from above than below the diaphragm. Repair of the stomach, colon, or upper jejunum is likewise not difficult by this route, and the rarity of lower abdominal visceral injury in thoraco-abdominal wounds is too well known to require reiteration. If laparotomy is required, as a rule it is to explore the upper abdomen, and a Kocher's incision has been found to give excellent access. Post-operative convalescence has been smoother with this than with the paramedian wound: where laparotomy can be avoided altogether, however, results are better still.

The type of thoracic operation is also subject to variation, most British surgeons being content with rib resection and closure of the pleura after repair of the diaphragm. Blood and blood-clot are, of course, removed from the pleura (which is closed without drainage) and a laceration of the lung may occasionally require suture. In the American Army, on the other hand, a more extensive operation is often done for right thoraco-abdominal wounds, involving the right leaf of the diaphragm and liver. The former is sutured and the retrohepatic area is drained after resection of the 11th and 12th ribs. Colonel Churchill (Consulting Surgeon, American Army) has stated that right-sided subphrenic abscess is common after liver wounds and bile empyema rare. In our series of 74 cases, by contrast, there has been but one subphrenic abscess after a liver wound and seven bile empyemata. The difference may well be due to the different techniques employed.

Of the 74 cases arriving at a Base hospital, 23 had already had a laparotomy, 18 a thoracotomy, and only 2 a laparotomy and thoracotomy. The great majority of the cases under review were operated on at a 'level' where X rays were not available

(Field Dressing Stations or Field Ambulances), but adequate operative treatment can go far to neutralize this apparent disadvantage. In the post-operative period, reliance should be placed on the aspirating needle in the absence of the radiograph, or in addition to the latter where X-ray facilities are available. Aspiration of blood and/or air is invariably required in these cases and is better done early and often than late or never. Here, of course, the experience of a physician, and particularly one skilled at aspiration, is of inestimable value, and the after-care of these cases is a combined problem. Breathing exercises and blood transfusion (at the fourth or fifth day) are among the points to which special attention has been paid. Complications, as will be shown later, are more frequent above the diaphragm, and undue attention is too often paid to the abdominal wound to the detriment of the thoracic lesion. A common example is rule-of-thumb venoclysis with its attendant danger of pulmonary œdema and bronchopneumonia.

A word may finally be included about the non-operative treatment of thoraco-abdominal injuries. This has a place, especially on the right side, but certainty of diagnosis is difficult, if not impossible, without radiography. A wound may, in fact, be labelled thoraco-abdominal only when: (1) A foreign body (with an entry wound in the chest) can be demonstrated below the diaphragm. (2) Hæmaturia is combined with a hæmo- or hæmopneumothorax. (3) The presence of a pleuro-biliary fistula is proved by paracentesis thoracis.

THE WOUND IN THE DIAPHRAGM

Immediate repair of the diaphragmatic wound does not as a rule present any difficulty. It is infinitely easier from above than below and, performed in two layers, gives satisfactory results. In most cases the lesion is too small to require repair or repair is thought unnecessary. This is particularly the case on the right side, where diaphragmatic hernia is not a danger. Among the 74 cases arriving at the Base, there were 2 of diaphragmatic hernia, but neither of these had had a laparotomy or thoracotomy. One had a coincident empyema and died after thoracotomy; the other revealed an extensive avulsion of the diaphragm from its anterior and lateral parietal attachments, and the free opening into the peritoneal cavity was at least 10 in. long. The defect was repaired (A. L. d'A.) by suturing the torn diaphragm to the chest wall above the line of its natural attachment and a successful closure obtained. Radiological confirmation five weeks after operation showed the division of cœlom from pleural cavity at a high level.

Impaired mobility of the diaphragm, which remains high long after operation in this type of wound, is a matter of common experience and should not give rise to concern in the absence of other signs and symptoms. It is also a feature of cases of simple hæmothorax.

COMPLICATIONS

Although the mortality-rate in those patients who survive the initial wounding and operative treatment is low, the morbidity-rate is high. The complications in the series of 74 cases quoted were :—

	Cases	
Hæmothorax	28	
Atelectasis	15	
Subphrenic abscess	12	(6 with coincident empyema)
Empyema	11	
Empyema with pleuro-biliary fistula	7	
Lung abscess	2	
Liver Abscess	2	

Hæmothorax, Atelectasis, and Lung Abscess.—The management of the hæmothorax is no different from that in a simple thoracic wound. Re-expansion of atelectatic lobes after postural drainage and MacMahon's breathing exercises is the rule and a course of sulphadiazine is often of value in reducing pyrexia, where progress is slow. Both the lung abscesses recorded in the table above resolved without operation, and experience has led us to believe that a course of parenteral penicillin, such as these two cases were given, is of the greatest value.

Empyema.—Perhaps the most significant feature is the high incidence of empyema (24 per cent), but by no means all of them were due to infection of a hæmothorax. A considerable proportion follow lower lobe collapses, associated with serous effusions that become purulent. In thoraco-abdominal wounds, therefore, a constant watch is essential and paracentesis thoracis is indicated, if the signs of effusion appear clinically or radiologically. Of the 18 treated in this series all made satisfactory recoveries, except one accompanying a large diaphragmatic hernia. The coexistence of subphrenic abscess and empyema is notable, and the injection of lipiodol followed by radiography is a valuable help in diagnosis.

Pleuro-biliary Fistula.—The diagnosis is easily made by pathological examination of fluid obtained by aspiration from the pleural cavity. The 7 cases quoted did well, but all developed empyemata—an interesting observation, when it is remembered that bile-salts were once used as a form of treatment for pleural empyema. They should be drained early, as loculation is likely if this measure is delayed. Re-expansion was rapid in all cases and disappearance of bile more rapid still. One patient had a secondary hæmorrhage from his liver, but survived after re-operation.

Subphrenic Abscess.—A total of 12 cases occurred, situated as follows :—

	Cases
Left posterior subphrenic space	6
Right posterior subphrenic space	1
Left anterior subphrenic space	2
Right anterior subphrenic space	3

Significant diagnostic features were hectic fever with its constitutional malaise, high leucocytosis, local tenderness and swelling, restricted rib movements, a diaphragm invisible radiologically with a fluid level beneath it, and an overlying sympathetic pleural effusion. Six cases had a coincident empyema and, in 2 of them, lipiodol demonstrated the two cavities and their communication. In the other 4, pus was seen to be coming up through the diaphragm at the operation for drainage of the empyema. Drainage of the subphrenic abscess was then carried out at the end of the chest intervention. All the

subphrenic abscesses were drained, the Ochsner route (resection of the 11th and/or 12th ribs) being most satisfactory for those posteriorly placed. Two right anterior abscesses were drained by anterior rib resection and extrapleural diaphragmatic incision, and the remainder were approached through abdominal incisions. All the patients recovered, except one Jugoslav woman soldier with a total right pyopneumothorax, a liver abscess, and a right intraperitoneal subphrenic abscess. She died of liver failure three months after admission.

THE PROBLEM OF RETAINED MISSILES

The causative missile is rarely seen during operations for thoraco-abdominal injuries, but should of course be removed if it comes easily to hand. In those with retained foreign bodies, the liver is a common site, but the fate of retained missiles is difficult to ascertain in this organ. No authoritative account has yet appeared in the literature, and it may be mere wishful thinking to suggest that they do not often cause mischief. Such is not invariably the case when missiles have been removed, as the following example shows :—

A man with a large sucking right thoraco-abdominal wound was operated on at a Field Ambulance twelve hours after injury. A very severe wound of the right ankle-joint with vascular injury required below-knee amputation, which was preceded by rib resection and closure of the chest wound, with transdiaphragmatic removal of a large metal fragment (2 in. × 2 in.) from the liver. Five days later the patient appeared to be doing well and aspiration of the chest on two occasions had revealed only a moderate amount of blood. Signs of septicæmia then appeared, from which he died on the eleventh day. Autopsy showed the amputation stump and pleural cavity to be clean, but the site of the foreign body in the liver was by now an abscess—with pyæmic abscesses in lungs and kidneys to confirm the diagnosis.

Missiles in the subphrenic region are also of interest and have been removed from beneath each diaphragmatic leaf. Furthermore, two have been removed from the perinephric space. The two truly subphrenic missiles illustrate many points of interest in connexion with these cases :—

1. Shell wound, abdomen ; jejunal resection ; right pleural empyema ; right subphrenic abscess ; recovery.—

A gunner was admitted to a Base Hospital four weeks after operation at a Field Dressing Station (Major F. E. Wheeler, R.A.M.C.). A grossly lacerated portion of jejunum was resected and progress was satisfactory until a pleural empyema developed, requiring intercostal drainage. A radiograph disclosed a shell fragment just below the cupola of the right diaphragm and lipiodol into the intercostal tube showed a track leading through a small diaphragmatic hole into a cavity between liver and diaphragm. From this cavity a track led to the shell fragment. At operation, resection of the 9th rib in the mid-axillary line showed the costophrenic sinus to be obliterated by adhesions. Incision of the diaphragm revealed an abscess cavity containing the fragment, which was removed. Recovery was uneventful. It seems clear that the missile, after traversing the abdomen, lodged in the diaphragm, causing a pleural empyema and then dropped back into an associated subphrenic abscess.

2. M.G. bullet wound ; left anterior intraperitoneal subphrenic abscess ; recovery.—

A commando soldier was shot through the left lower chest at close range. Ten days later he had left upper abdominal pain and pain referred to the left shoulder tip. There was a minimal left pleural effusion. Radiology disclosed a bullet lying below the centre of the left dome of the diaphragm. A left transthoracic approach was employed through the bed of the resected 7th rib. The left lower lobe was adherent to the diaphragm and separation exposed an inflamed area of that structure. This was incised and the bullet removed from a small abscess cavity between it and the left lobe of the liver. This abscess was carefully mopped out and sulphanilamide powder left in it ; the diaphragm and chest were then sutured without drainage. A left pleural effusion required several post-operative aspirations, but recovery was satisfactory.

Foreign bodies in thoracospinal wounds can likewise give rise to trouble, especially when there is bone damage to the vertebral column, but complications such as this are outside the scope of this paper. So, too, are the associated wounds, which so often determine the issue.

SUMMARY AND CONCLUSIONS

1. Of 126 thoraco-abdominal wounds treated in Forward areas, 46 proved fatal (36·5 per cent).

2. Of 74 patients with thoraco-abdominal injuries arriving at a Base Hospital from Forward areas only 3 died.

3. The all-in mortality-rate of thoraco-abdominal wounds treated by surgery is 38·9 per cent.

4. Thoraco-abdominal wounds are less serious than abdomino-thoracic.

5. Solid viscus injury in the abdomen in these cases is more frequent than that of hollow viscera and is prognostically less serious.

6. Laparotomy should be avoided, where possible, in favour of thoracotomy and the transdiaphragmatic approach to the abdomen. If laparotomy be required, a Kocher's incision gave good results in our hands.

7. Conservative treatment in cases properly selected and controlled gives excellent results, e.g., as in many cases of retained liver missiles without evidence of other intraperitoneal mischief.

8. Diaphragmatic hernia is uncommon as a sequel of thoraco-abdominal wounds.

9. The complications most commonly encountered are hæmothorax, atelectasis, empyema, and subphrenic abscess.

10. Pleuro-biliary fistula with empyema occurred in 7 of 74 cases. All recovered.

11. The fate of retained missiles, especially in the liver, is difficult to assess.

We are indebted to Majors F. E. Wheeler, E. H. C. Harper, H. G. Estcourt, and C. G. Rob for their figures of operations in Forward areas ; and to Major J. W. Litchfield, Medical Specialist, and Major C. J. Hodson, Radiologist, for their co-operation in the management of these patients at a Base Hospital.

REFERENCES

CHURCHILL, E. D., personal communication.
GORDON-TAYLOR, G. (1944), *Brit. J. Surg.*, **32**, 247.
— — (1943), *Ibid.*, **30**, 105.

PRINCIPLES IN EARLY RECONSTRUCTIVE SURGERY OF SEVERE THERMAL BURNS OF THE HANDS

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The frequent disabilities and deformities resulting from the improper treatment of burns of the hands makes a satisfactory method of therapy worthy of reiteration and discussion. It is not our intention to claim originality or denounce other forms of treatment. The results obtained by the method of therapy described in this paper are attributed to the observation of numerous details.

A large number of war-time burns occur as a result of exposure to gasoline flames in aircraft, mechanized equipment, and field ranges. Characteristically, there is thermal destruction of the tissues, of the lips, nose, upper face, eyelids, brows, forehead, ears, dorsum of the hands, and encircling burns about the wrists. Unlike burns encountered in civilian life, the rapidity and depth of tissue destruction in a burning aircraft is often influenced by the presence of oxygen, as well as high octane gasoline. The majority of aircraft burns occurs in take-off and landing accidents.

Prevention and minimization rests in the proper wearing of protective fire-resisting headgear and gloves. Although the operation of military equipment is rendered more difficult by the employment of fire-resisting apparel, the insurance offered by the burden is worthy of consideration.

Since modern literature is flooded with the initial systemic, supportive treatment of early burns, its importance requires no emphasis. Transportation of the burn casualty to a hospital equipped for definitive treatment should be accomplished immediately. After seven hours, and often sooner, the development of secondary shock renders transportation hazardous.

Meticulous care should be taken to prevent infection. Initial success depends upon protection of the wounds from contamination by organisms harboured in and about the orifices of the body of the patient and attendants. Relaxation of aseptic technique is inexcusable. Initial conservation débridement is of value if strict surgical precautions are observed. Medical attendants and the patients should always wear a cap and mask when the wounds are exposed. Floor dust in the atmosphere from recent sweeping constitutes a frequent source of wound contamination. Use of so-called 'clean' bandage scissors may inoculate pathogens. The most common organisms found in infected thermal burns are hæmolytic streptococci, hæmolytic staphylococci, *B. pyocyaneus*, *B. coli*, and *B. proteus*.

The general condition of the casualty during the first three days often demands immobilization of the hands. It is during this time that œdema develops in all of the soft tissues of the hands and fingers. If pressure dressings are used they should not be tight enough to interfere with circulation in the hand and fingers. To combat œdema, the hands should be elevated high above the level of the heart. Proper initial elevation is an important prerequisite to good treatment. The ideal position of the hand is mid-flexion of the fingers and 45° extension of the wrists, with the arms suspended by means of two padded full-length arm splints, flexed 20° to the elbow for comfort. It is a common error to allow the patient to rest the hands on the chest with the wrists flexed and the fingers extended. (*Figs.* 179, 180.) Support of the hands and arms

Fig. 179.—Correct posture of the hands in an elevated position suspended from an orthopædic frame. Mosquito bar is draped over the frame to protect the patient from fly and maggot infestation of the burns.

on pillows may be utilized. The most effective means of elevation is suspension from an orthopædic frame or an overhead beam. Elevation is continued after exercises have been started.

As early as three days after the injury active motion is instituted. The technique of motion entails the use of an arm tub with submerging exercises under the direction of an experienced and qualified physiotherapist. The immersion bath consists of tepid sterile physiological saline solution. Encouragement and psychotherapeutic suggestion is given by all attendants dealing with the patient. The sterile gloved hand of the physiotherapist may be used to demonstrate the amount of passive motion the patient should command by active muscualr activity. Exercise in the bath is well tolerated for one half hour three times daily. At one period each day the dressings are floated off to permit exercises without the limiting effect of bandages. The digits are bandaged independently to prevent webbing and to allow greater freedom of movement. Deep

third-degree burns are not incompatible with complete flexion of the fingers.

The most common result of delayed early motion is an extension deformity of the hand. The wrist

FIG. 180.—Improper position of the hands on the chest with fingers extended and wrists flexed. The fingers are bandaged independently to allow motion and prevent webbing.

is held in flexion and motion of the fingers is executed only in the metacarpophalangeal joints. The fourth and fifth digits tend to develop a deformity characterized by hyperextension of the proximal phalanges and acute flexion of the distal phalanges.

FIG. 181.—*Case* E. B. First- and second-degree gasoline burns of the dorsum of the hand and fingers supported on a sterile débridement tray. Treated with vaseline gauze and exercises. Complete restoration in three weeks.

It is difficult to determine the depth of a severe burn until demarcation of slough is established (*Figs.* 181, 182). The type of dressing employed in selected with the desire to promote early separation of slough and to prepare the wound for grafting. As demarcation takes place the slough is excised by delicate meticulous dissection under pentothal anæsthesia. If extension of the digits has superseded the desired degree of flexion, the fingers are gently placed and dressed in acute flexion for twenty-four hours. Forceful manipulation of the digits in an attempt to break adhesions should not be done. Resulting œdema, hæmorrhage, and destruction of peri-articular tissues may initiate an irreparable loss of function. Granulations are grey and covered with a slimy mucopurulent discharge following the prolonged use of vaseline gauze dressings. The granulating areas become pink, friable, and bleed easily when sulphanilamide crystals and saline dressings are substituted. Saline dressings prepare the wound for grafting in twenty-four to forty-eight hours.

Scar tissue forms in the base of the granulating bed in an early phase of the reparative process and continues until epithelialization is complete. It has

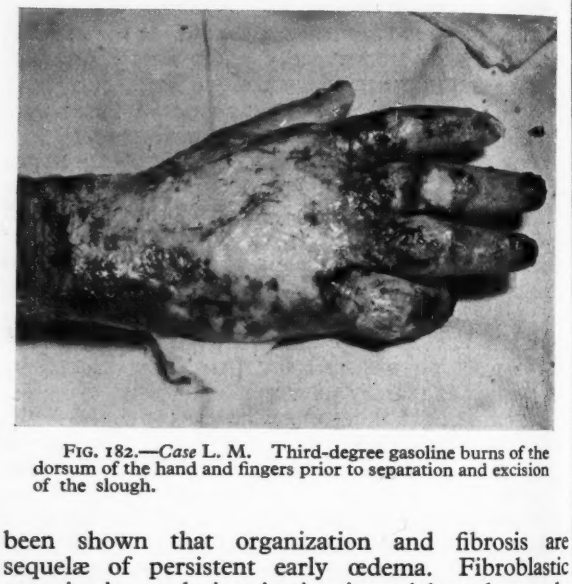

FIG. 182.—*Case* L. M. Third-degree gasoline burns of the dorsum of the hand and fingers prior to separation and excision of the slough.

been shown that organization and fibrosis are sequelæ of persistent early œdema. Fibroblastic organization and cicatrization is anticipated as early as twelve days. Surgical epithelialization is the means of arresting the process of scar tissue formation. Decrease in local pain and diminution of the exudation from the wound parallels a favourable turn in the tide of infection. Although it is considered scientific to use bacteriological studies as a gauge in the determination of therapy, it may be ignored as a factor in the time to graft the burned hand. Regardless of the bacterial flora, early grafting of the wound is imperative.

Laboratory determination of total blood-proteins, albumin, globulin ration, hæmoglobin, and red-cell count are taken as an index for the administration of blood and plasma in preparation for operations.

ANÆSTHESIA

Pre-operative medication is individualized. Although the type of anæsthesia employed is occasionally dictated by the systemic condition of the patient, it is preferable to employ inhalation anæsthesia. Light anæsthesia decreases the tendency to shock. Unless muscle relaxation is required for technical reasons, deep anæsthesia in the burned individual is undesirable. The anæsthetic time is reduced when a separate surgical team simultaneously

operates on each burned area. If burns about the head are being dressed or grafted at the same time, intratracheal anæsthesia offers less technical interference in the operative fields, maintains a patent airway, and facilitates removal of mucus from the trachea. Packing of the nose and mouth prevents the aspiration of irrigating solutions and blood. Closed-system either oxygen or ether administered by a Flagg can is a simple efficient method. Novocain block and pentothal anæsthesia may be necessary in selected cases, but is not usually recommended for the procedure. During the anæsthetic the administration of fluids, plasma, or blood is frequently necessary.

SURGICAL TECHNIQUE

We have found that grafts will grow as early as eleven days following thermal destruction of the dermis. Fractures interfere with early activity, but should not prevent early grafting. Compound fractures, open joints, exposed tendons, or bone surfaces have not been a contra-indication to early grafting. Unreasonable as it may seem, we have succeeded in closing open joint spaces and covering bones and tendons with viable split-thickness grafts. Failure of the graft locally over exposed tendons of deficient viability has been followed by rapid proliferation of epithelium from the adjacent graft margin.

In a wound ready for grafting one may observe thin shiny labile epithelium around the margins of the wound as well as small islands of feeble epithelium. Such tissue is of poor quality and is easily dislodged from its underlying base of cicatrix. The burned area is thoroughly scrubbed with neutral soap on a gauze sponge and irrigated with sterile water. The mechanical action of cleansing removes much of the thin, poorly organized epithelium. A blood-pressure cuff applied to the upper arm is used to control bleeding. A sharp Ferris Smith blade provides a useful instrument for the radical excision of granulation tissue and slough. The wound is gradually sliced down until a smooth firm base is encountered. All granulations, islands of sparse epithelium, and skin margins are included in the excision. (*Figs.* 183–186.) Areas not amenable to slicing may be prepared with a mastoid curette. Large sheets of split-thickness graft are required to cover the hand. These are obtained in the desired uniformity by means of a Padgett dermatome. Grafts for the dorsum of the hand cut $\frac{1}{100}$ in. in thickness have offered the best technical and cosmetic qualities.

It is desirable to take skin from an area which will cause the patient as little post-operative discomfort as possible. The available skin from which the graft is cut may be limited by the distribution of burns over the body. Thick grafts should not be taken from the thin skin covering the adductor surface of the thigh or medial aspect of the arm. Thick split grafts from the anterior, lateral, and posterior surfaces of the thigh are well tolerated. It is technically less difficult to secure a full drum of skin from the average thigh in the horizontal meridian than it is by cutting in the longitudinal axis of the thigh; also it is more economical if the available healthy skin is limited. The abdomen is a useful donor area. When the chest is selected as a donor site, injury to the nipples is avoided by careful observation of the blade in action. If the drum is destined to pass over the breast, the nipple may be protected by the local application of vaseline to the areola after the surrounding skin has been painted with rubber cement. Emaciation and prominent ribs offer technical difficulties which are easily eliminated by a preliminary subcutaneous injection of saline beneath the depressed areas of skin. In elevating the skin over the depressions of the chest with saline, care should be taken to avoid entering the pleura. The skin of the back and buttocks may be used as a donor site if necessary. Due to the fact that most burned patients prefer to rest in the supine position, an attempt to avoid the back as a donor site is a humane gesture by the surgeon. In our experience it is advantageous to leave the distal end of the graft attached to the adjacent normal skin until the drum is pealed loose from the graft. Not only does this manœuvre strip the rubber from the surface of the graft, but saves time and unnecessary manipulation of the graft in mid air.

Usually a drum and a half of skin will cover the dorsum of the hand, fingers, and thumb. Sulphanilamide crystals dusted on the surface of the graft will mechanically inactivate the adhesive qualities of residual rubber cement.

The raw surface of the skin-graft is covered by tissue fluid which contains valuable hæmostatic agents. To preserve this hæmostatic property the graft should neither be sponged nor washed with saline, but placed directly on the surface of the prepared recipient bed. Gentle pressure applied against the graft will stop the oozing of blood. After pressure for a few minutes persistent bleeders may be controlled by clamping and twisting. Ligatures and hæmostatic sutures introduce undesirable foreign material beneath the graft and should be avoided if hæmostasis is obtained without them. Reapplication of the tourniquet pressure cuff may be occasionally required. A tourniquet should not be applied for more than twenty minutes without allowing an interval to resume circulation in the extremity. A twenty-minute period of application of the tourniquet is considered maximum in view of the circulatory changes which are already present as a result of the burn. To obtain the best healing results the graft is stretched uniformly, and as tightly as possible. Fixation is attained by interrupted sutures. To maintain tension it is necessary to suture the graft to healthy skin. Excessive overlapping of graft is trimmed close to the sutures to prevent collection of fluid under the non-viable overhanging graft margin. Two types of sutures have been used. Medium dermal nylon ooo, and ooo braided silk. It is felt that the only necessary feature of the suture material is strength sufficient to maintain tension in the graft. An additional advantage in the use of heavy materials is the ease with which the sutures may be placed and tied. Pattern cutting is not considered necessary. When the graft is stretched into its taut position the finger extensions are split away from the graft down to the web. Perforation of the graft is not done as

the technique of tension and hæmostatic action of the graft itself has been found sufficient to prevent the accumulation of serum and blood. Penicillin, small amounts of sulphanilamide, or a plasma coagulum did not seen to hinder or aid in our results. An ideal storage place for the graft before it is applied is the donor wound itself, rather than in a saline sponge on the instrument table. The dressing of the applied graft should be one which will not become adherent. Rubber cement remaining on the surface of the graft is an undesirable feature. Xeroform gauze or sulphanilamide crystals with dry gauze minimizes sticking. Cotton batting is applied and the hand wrapped in a pressure elastic bandage with the fingers acutely flexed. The wrist is cocked in extension on a padded basswood splint. The graft is allowed to remain dry twenty-four hours before saturating continuously with saline from a sterile syringe.

The dressing of the donor area consists of a double layer of vaseline gauze or tulle gras, over which is placed a thin layer of sterile gauze and an abdominal pad. The pad is supported in position by elastic bandage, elastoplast, or wide strips of adhesive plaster. The outer pad may be replaced when the odour is offensive. The vaseline gauze usually becomes adherent to the donor wound and should not be removed until is spontaneously separates itself. Healing of the donor site usually requires about ten days.

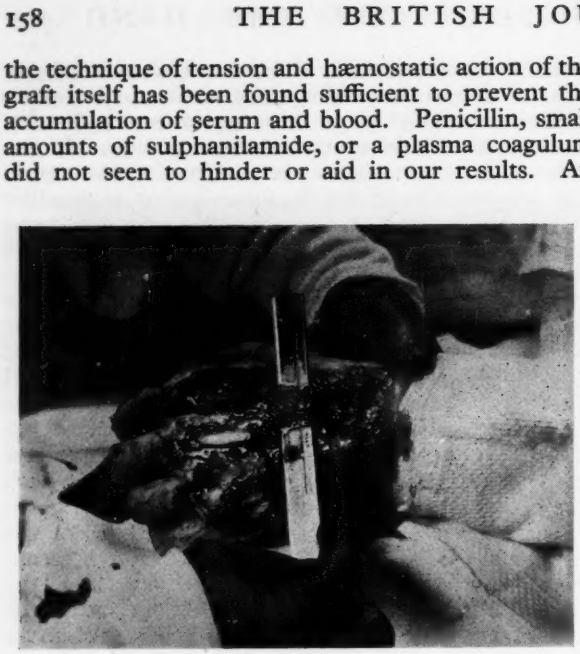

FIG. 183.—*Case* J. V. Excision of slough, granulation tissue, and labile epithelium by sharp dissection.

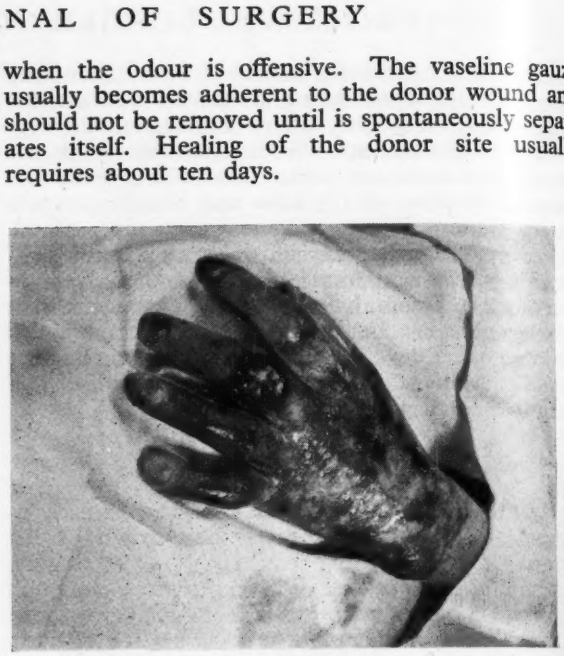

FIG. 184.—*Case* L. M. Recipient bed after surgical preparation.

FIG. 185.—*Case* L. M. Split-thickness graft $\frac{1}{100}$ in. in thickness sutured into position.

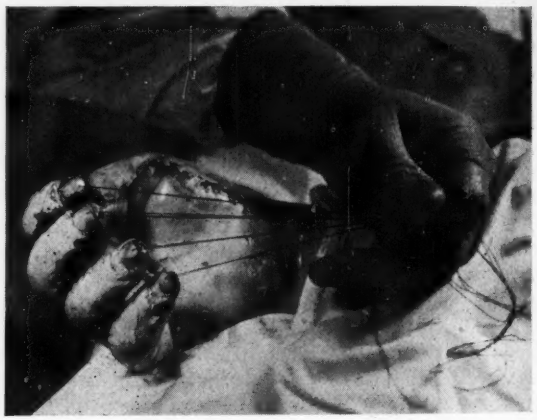

FIG. 186.—*Case* J. L. Traction sutures through the finger-nails to aid in the position of acute flexion during the immediate post-operative period.

POST-OPERATIVE CARE

The total period of splinting and post-operative elevation is five days. Dressings are washed away in an arm tub bath on the fifth day. Meticulous care and abundant saturation is required to prevent the separation of the graft from its recently acquired bed. Cocoa butter is applied to the surface of the graft and further dressings are eliminated. During the daytime while the patient is awake the graft needs no protection other than good co-operation of the patient. At night the graft is covered with a well-padded loose dressing to protect the hand from trauma during sleep. The submersion baths are resumed three times a day. Elevation is continued when the hand is at rest. The rehabilitation exercises are directed towards flexion and extension.

The ease with which the motion of adduction of the thumb to the extended fingers is performed cannot be selected as a criterion of good function.

Restoration of normal function in a hand is dependent upon a wide range of motion in the interphalangeal joints. Unless the patient is specifically instructed, a tendency to substitute motion in the metacarpophalangeal joints for flexion and extension of the interphalangeal joints is outstanding. Neglect of early full motion of the interphalangeal joints is an open invitation to permanent dysfunction and deformity. Encouragement and constant attention is demanded if good functional results are expected.

Elevated healed edges around the graft at the junction with normal skin is only of temporary cosmetic concern. Spontaneous levelling of the margin and blending of the graft with normal skin occurs during rehabilitation and requires no surgical intervention. Transient cyanosis in the graft during the post-operative period is not uncommon. The appearance of a serous subepithelial bleb is an indication of excessive dependency of the extremity or activity beyond the tolerance of the graft. Elevation should be increased, activity decreased, and bullæ aspirated. Occupational exercises and clay modelling are extremely effective. (*Figs.* 187, 188 depict early final results.)

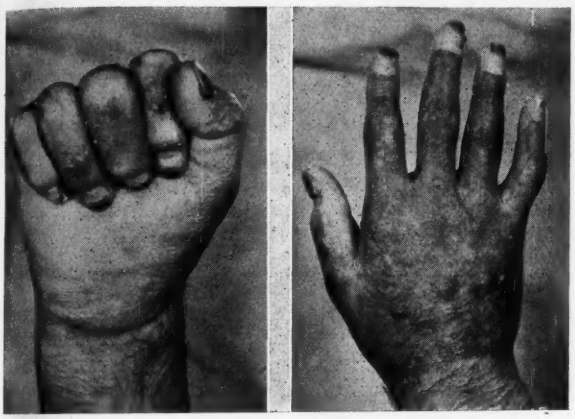

FIG. 187.—*Case* J. L. Third-degree gasoline burn of the hand incurred in a plane crash May 20, 1944. Split-thickness graft June 2. Same case as shown in *Fig.* 186. Photographed June 28, 1944, showing restoration of function.

FIG. 188.—*Case* A. M. Third-degree gasoline burn of the hand in plane crash May 2, 1944. Split-thickness graft June 19, 1944. Photograph of July 5 demonstrates complete viability of the graft except a small area overlying a necrotic extensor tendon of the third finger. Small subepithelial blebs are present on the lateral volar aspect of the thumb. Functional activity approaches normal.

SUMMARY AND CONCLUSIONS

1. Deformity and disability resulting from thermal burns of the hands may be reduced by early management.

2. Regulations directing the proper use of protective fire-resisting apparel will reduce burned hazards in military operations.

3. Characteristic war-time burns of the hand involve the tissue over the dorsum of the hand and fingers, with a tendency to encircle the wrist.

4. Initial treatment is directed toward prevention of infection and restoration of function.

5. Infection and exposed tendons and bones do not contra-indicate early grafting.

6. Radical excision of slough, granulation tissue, and poorly developed epithelium prepare the recipient surface for a split-thickness graft.

7. The graft is sutured in place under the tension of normal skin.

8. Post-operatively, dressings and splints are removed on the fifth day.

9. Rehabilitation exercises are resumed until maximum functional activity is accomplished.

10. Our success in the treatment of burned hands is attributed to the execution of the numerous suggestions outlined in the text of this paper.

BIBLIOGRAPHY

BARRON, JOHN, personal communication.

BRICKER, EUGENE, personal communication.

BROWN, J. B. (1938), *Ann. Surg.*, **107**, 953.

— — (1941), *Surg. Gynec. Obstet.*, **72**, 265.

— — (1943), *Skin Grafting and Contractures Following Burns. Burns, Shock, Wound Healing, and Vascular Injuries.* Philadelphia and London: W. B. Saunders Co.

MCINDOE, A. H. (1941), *Lancet*, **2**, 377.

Management of the Cocoanut Grove Burns at the Massachusetts General Hospital (1943). Philadelphia and London: J. B. Lippincott Co.

MOWLEM, R. (1940), *Brit. med. J.*, **2**, 844.

PADGETT, E. C. (1939), *Surg. Gynec. Obstet.*, **69**, 779.

WAKELEY, C. P. G., WILSON, W. C., FLEMMING, CECIL, WITTS, L. J., MCINDOE, A. H., BUNYAN, JOHN, GILLIES, HAROLD, JUDSON, R. V., COLEBROOK, LEONARD, and KILNER, T. P. (1940), *Proc. R. Soc. Med.*, **34**, 43.

WOLFSON, SAMUEL J., personal communication.

AN AID IN THE POST-OPERATIVE MANAGEMENT OF TEMPORARY ILEAL FISTULA AFTER THE LAHEY RIGHT HEMICOLECTOMY

By SAMUEL LEVY
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THE modification of the Paul-Mikulicz plan of operation for lesions necessitating right hemicolectomy, as described by Lahey (1939), claims several advantages: first, it is not a difficult operation to perform; secondly, the operation can be performed in the presence of obstruction, without the necessity for any preliminary operative decompression; and finally, but by no means the least important, by minimizing the danger of peritonitis, a significantly low mortality-rate has resulted from its use. Thus Lahey and Colcock (1942) report a total mortality-rate of 13 per cent by employing the Lahey method of right hemicolectomy for all types of lesion, when the operability rate in the same series was 85 per cent. For the cancer cases in this series, however, they claim a mortality-rate of only 3 per cent. Other observers, using various other techniques, claim mortality-rates varying from just under 12 per cent to over 23 per cent in several series of cases (Rankin, 1932). However, as so few surgeons publish the mortality-rate of a particular method of operation in relation to the operability-rate for that method, comparisons of mortality-rates are therefore not as significant as one might wish. It will be conceded, nevertheless, that a 3 per cent mortality-rate for cancer cases undergoing right hemicolectomy, in the series of cases mentioned above (Lahey and Colcock, 1942), is significantly low, and that the operation can justly claim to be associated with a high degree of safety.

The presence of a terminal ileostomy, even although temporary, is, however, a serious disadvantage of this technique, and is a deterrent to its wider adoption. Thus Gordon-Taylor (1944) remarks that "Paul-Mikulicz procedures on the right side of the belly sometimes may prove a burden scarcely to be borne". On the other hand, Maingot (1942), whilst recognizing the temporary, although trying, burden to the patient of a temporary ileostomy, points out that "this is the price . . . which the patient has to pay for added security".

The object of this paper is to describe a method of managing the ileostomy which in my experience has been found considerably to ease the burden not only of the patient but also of the nursing staff, thereby ensuring to the patient the boon of a safe operation with a minimum of post-operative discomfort.

Usual Management of the Ileostomy.—The usual history of the post-operative period following a Lahey right hemicolectomy is as follows: For the first 7 to 10 days after the operation the ileostomy drains, either through a tied-in wide rubber catheter or a Paul's glass tube with attached rubber tubing, into a bucket or other receptacle at the side of the bed. Soiling of the skin by ileal contents, with consequent skin irritation and excoriation, and seepage through the dressings, are thus avoided. At the end of this time, however, the Paul's tube or catheter works loose owing to sloughing of the tied staggered end of ileum. These sloughs are trimmed off and an enterotome is then applied to crush the spur. The ileostomy now discharges into the dressings and on to the skin. The skin, despite protective pastes, becomes excoriated, and the ileal discharge is on occasion so profuse that it not only soaks the dressings but also seeps into the patient's attire and sometimes even into the bedclothes. This seepage, with occasional floodings, of odoriferous, irritating, ileal discharge causes the patient distress, anxiety, and lack of mental and physical rest. To minimize irritation of the skin and provide for the comfort of the patient, frequent copious dressings of wool and gauze are needed. Furthermore, the enterotome requires to be supported by a bulky gauze and wool dressing, which because it not only requires frequent renewal, but also tends to 'ride' up or down on the abdomen, can only act as an uncertain enterotome support. The enterotome generally cuts through the spur in 5 to 8 days, and may have to be re-applied if the spur is considered to be insufficiently crushed by its first application. Whilst the enterotome is in position, the whole of the ileal discharge is on to the skin and into the dressings. When the spur is crushed to a sufficient depth there is a waiting period of 6 to 8 weeks to allow the œdema of the exteriorized bowel to subside before the fistula should be closed. During this waiting period, the mouth of the fistula can be plugged with a wool or gauze spigot so as to shunt the ileal contents into the colon; but even the spigot cannot prevent leakage, with even occasional floodings, of irritating fluid on to the skin.

The stages in the treatment of the ileostomy, outlined above, may be summarized thus:—

7–10 days after operation:	Paul's tube tied in. No leakage.
10–17 days after operation:	Enterotome applied. Ileostomy discharges on to skin and into dressings. Skin around fistula red.
3–9 weeks after operation:	Ileostomy spigot in use. Some stools, but most of the ileal discharge into dressings. Skin red and excoriated.
10th week after operation:	Closure of fistula.

AUTHOR'S TECHNIQUE

The Ileostomy Pan.—To overcome the disadvantages arising out of the presence of the ileostomy, the ileostomy pan was devised, tried out, and found highly successful in eliminating the effects of the ileal stream by automatically diverting the irritating fluid away from the fistula without soiling the skin or dressings.

The pan resembles in shape an ordinary bed-pan in miniature. It is made of light aluminium alloy, about $\frac{1}{16}$ in. thick, or of celluloid. The pan has a flat base, circular concave walls, and an outlet tube.

The diameter of the base is 5 in., with a central, circular, inlet hole 3 in. in diameter. The inlet is large enough to embrace the ileostomy and attached transverse colon fistula, whilst the surrounding flat base provides wide circular apposition to the abdominal wall and at the same time acts as a stage for draining the ileal discharge directly into the outlet tube, or indirectly into the tube via the concave circular walls of the pan. The surrounding circular wall is concave inwards so that when the pan is in position, the obliquity of the anterior abdominal wall causes the concave walls of the lower half of the pan to act as a gutter for conveying discharge into the outlet tube. The outlet tube is fused to the pan so that its floor is on the same plane as the base of the pan, so as to avoid any pooling of liquid. The walls are 2 in. high, and the outlet tube 1 in. in diameter and $1\frac{3}{4}$ in. long. The pan is open above, or when the enterotome is no longer in use, it can be covered with a lid. To the outlet tube is tied a long piece of inner bicycle tubing (*Fig.* 189) for conveying the fluid into a bucket or

FIG. 189.—Vaseline gauze pads are in position. The edge of the hole in the centre of the pads is tucked in around the bowel. The tubing is attached to the outlet tube. Ileal contents can be seen spilling out and draining towards the outlet tube.

other receptacle at the side of the patient's bed. This kind of tubing, because of its firmer walls and, therefore, patent lumen, was found to be more suitable than Paul's tubing, the walls of which tend to adhere and so occlude the lumen, resulting in damming up of fluid in the pan.

The Use of the Pan.—The pan has so far only been used when the fistula has been sited at the upper end of a right paramedian incision (*Fig.* 191). This position for the fistula has been chosen in preference to bringing it out through a lateral stab incision because the more medial site enables the pan to be applied snugly and securely on the comparatively more horizontal surface of the anterior abdominal wall. Nursing the patient in Fowler's position ensures that the fluid gravitates easily into the outlet tube. Furthermore, it is believed that medial siting of the fistula, as opposed to more lateral siting, minimizes considerably the well-known tendency of the exteriorized bowel to retract within the abdominal cavity. Complete retraction of the fistula into the abdominal cavity through a lateral stab

FIG. 190.—The pan is maintained in position by firmly strapping overlapping strips of elastoplast. When the enterotome is in use two lateral strips are required in addition to provide lateral support.

incision within the first few days after operation is an accident not unknown.

After the skin incision is sewn up, it is sealed by applying gauze soaked in collodion, which, after drying, is covered with more gauze and then elastoplast, thus securely sealing off the wound. This seal enables the pan to be applied, if need be, to the fistula even before the skin sutures are removed. Sepsis in the laparotomy wound has not been encountered.

The skin around the fistula is thoroughly washed, dried, and then smeared with Ballerina paste or vaseline. Two gauze pads, each about six layers thick and about 7 in. square, and thickly impregnated with vaseline or Ballerina paste, are superimposed on each other. A hole is then cut in the centre of the two pads just large enough to allow the exteriorized bowel to be passed through it. When in position, the edge of the gauze hole is tucked up snugly to the bowel wall at its junction with the skin (*Fig.* 189). To render the latter junction watertight, 1-in. vaseline gauze is wound around the base of the protruding bowel so that some of this gauze overlaps the gauze pad. The pan is then placed in position so that the fistula protrudes into it through the inlet hole, whilst the outlet tube is so placed that it is at the lowest point of the wall of the pan (*Fig.* 189). The vaseline gauze pads, it should be noted, are not overlapped by the base of the pan. The pan is held in position by the firm application of strips of elastoplast running transversely, each succeeding strip overlapping the first by half its width. Care is taken to see that the upper and lower limits of the pan are well strapped down and sealed off (*Fig.* 190). The firm pressure thus obtained ensures a watertight junction between

the pan and the gauze, and also between the gauze and the skin should any leakage occur under the gauze pads at their junction with the bowel wall. The elastic pressure ensures uniform and continuous pressure of the whole base of the pan against the abdominal wall, despite the respiratory movements and the varying postures the patient adopts during sleep. The waterproof elastic strapping prevents spillage of liquid even without the use of a lid. When the enterotome is in position excellent support for it is maintained by the additional application of two lateral strips of strapping (*Fig.* 190).

FIG. 191.—Photograph showing the condition of the skin of the abdominal wall eight weeks after a right Lahey hemicolectomy for Crohn's disease. Vaseline pads and the pan had been in use for six weeks before this photograph was taken.

Whilst the pan is in use it is an advantage to feed the patient on a residue-free diet since fruit skins and other cellulose residue tend to stagnate in the pan.

Advantages of the Pan.—The use of the pan overcomes many of the disadvantages arising from the presence of the ileostomy. The vaseline or Ballerina pads and strapping require readjustment about twice weekly, and if carefully applied, the pan only needs readjustment about every fifth day. There is thus a very considerable saving not only in the number of dressings and quantity of dressing material used, but also of the exertions of the nursing staff. The patient is thus not disturbed by the almost incessant spillage and leakage of ileal contents on to his skin and into and outside the dressings as occurs when massive gauze and wool dressings alone are used, and he is, moreover, able to move about freely in bed without fear of spillage or of moving the dressings; adequate and undisturbed sleep can thus be promoted. Skin excoriation is obviated or minimal. These advantages are reflected in the cheerfulness and sense of well-being of patients so nursed, in contrast to those patients who had been nursed by using massive gauze and wool dressings. Lastly, the strapping provides all-round steadying support for the enterotome when in use.

SUMMARY AND CONCLUSIONS

1. Right hemicolectomy using the Lahey modification of the Paul-Mikulicz plan of operation is associated with a significantly low mortality-rate; it can be performed in the presence of obstruction without prior decompression, and is not a difficult operation.

2. The chief disadvantage of this operation arises from the effects of the ileal contents discharging on to the skin and into the dressings for several weeks.

3. These disadvantages are overcome by the use of the ileostomy pan, which, by automatically diverting the ileal stream away from the fistula without leakage on to the skin or into dressings, prevents skin excoriation, avoids the necessity for copious and frequent dressings, and thus enables the patient to get adequate mental and physical rest. Furthermore, more reliable fixation of the enterotome is obtained by this method than with gauze and wool dressings alone. Lastly, but not least in importance, the use of the pan drastically spares the exertions of the nursing staff.

I wish to thank the Director-General, Emergency Medical Service, for permission to publish this paper.

REFERENCES

GORDON-TAYLOR, G. (1944), *Brit. J. Surg.*, **32**, 254.
LAHEY, F. H. (1939), *Amer. J. Surg.*, **46**, 3.
— — and COLCOCK, B. P. (1942), *Surg. Clin. N. Amer.*, **22**, 773.
MAINGOT, R. (1942), *Med. Pr.*, **208**, 164.
RANKIN, BARGEN, and BUIE (1934), *The Colon, Rectum and Anus*. Philadelphia and London: W. B. Saunders Co.

EXPERIENCES WITH TRANSTHORACIC ŒSOPHAGECTOMY AND GASTRECTOMY

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ŒSOPHAGECTOMY is becoming quite a common operation, and a recent paper by Thompson (1945) (who has the credit of performing the first successful œsophagectomy with direct anastomosis in this country) sums up the present position. It may be of interest to record experiences with this operation, which, in spite of the advances which have been made, remains a formidable proceeding. The chief reason for this danger is, of course, the type of patient most commonly encountered, the poor half-starved old man whose general condition makes for inoperability even if his growth does not. That age has

an important bearing on the outcome is not surprising; a study of the ages of any reported cases will show that the recoveries are mostly in the 50's, less often in the 60's, and hardly ever over that. Encouragement may be taken from the fact that the patient of 72 in this series came through his ordeal with less upset than almost any of the others; nevertheless, the vital capacity of a man of over 65 is diminished, and he is liable to stand a prolonged thoracotomy badly. Where the alternative, however, is certain and miserable death, it behoves the surgeon to take his courage and his patient's life in both hands and attack the problem boldly.

The optimum portion of the œsophago-gastric tract for transpleural ablation is the lower third of the œsophagus and the upper third of the stomach. All Trotter's ingenuity and artistry could not produce a high percentage of cures after excision of post-cricoid carcinomas, and it is unlikely that his skill will be excelled. Carcinoma of the mid-œsophagus invades its vital surroundings at an early stage, and even when successfully removed presents serious problems of restoration of continuity. Too often the story of skin-tube repair is one of repeated operations with the patient dying before the last one succeeds, and it is probably better to wait a year after extirpation of the growth to see if recurrence is going to take place before embarking on such measures. A reasonably young subject will stand the multiple procedures involved in bringing the stomach (Kirschner, 1920; Taylor, 1945), or intestine (Yudin, 1944) up to the œsophageal stump antethoracically, but the usual elderly patient will not. Removal and reconstitution of the juxta-cardiac œsophagus and stomach, however, presents no serious technical difficulties even to the general surgeon, and the indications for surgery in this region are now well established with the prospect of completion of a satisfactory one-stage operation.

Total gastrectomy by the abdominal route is always liable to cause anxiety as to the soundness and lack of tension of the anastomosis even if the lower end of the œsophagus is well mobilized. Transthoracic total gastrectomy, of which the biggest series of cases so far has been reported by Churchill and Sweet (1942, a), gives rise to no such fears. In fact, an operation for carcinoma of the fundus involving the œsophagus which is mechanically impossible from below, becomes a simple matter when approached from above. However, a large growth of the fundus may, by its size alone, increase the technical difficulties to such an extent that the consequent prolongation of the operation is more than can be withstood, and such a growth, although mobile, should be considered inoperable in an elderly patient. An old man will stand an open thoracotomy lasting 1½ hours, but is unlikely to survive a 2-½ to 3-hour period.

Non-malignant conditions will rarely require to be approached other than abdominally, but it was decided in *Case* 8 to approach from the thorax on account of the likelihood of massive adhesions and the desirability of this course was borne out by the findings. The ease with which the spleen is removed in the course of operating on the fundus suggests the possibility of the thoracic route being employed when dense adhesions to the diaphragm seriously hinder an abdominal splenectomy.

CASE REPORTS

The following cases illustrate certain practical points which will be dealt with subsequently. Cases which have been explored and found inoperable have not been included.

a. Failures.—

Case 1 (June 30, 1941).—G. B., male aged 68, 2 weeks' history. Mid-œsophageal carcinoma. Gastrostomy followed by left-sided resection with exteriorization of upper end of œsophagus. Died 2 days later, œdema of lungs.

Case 2. (July 6, 1943).—H. D., male aged 72, 3 weeks' history. Carcinoma, lower third of œsophagus. Left-sided resection and anastomosis.

Died 24 hours later, collapse of lung.

Case 3 (Oct. 22, 1944).—S. S., male aged 63, 6 months' history. Large adenocarcinoma of fundus involving cardia, spleen, tail of pancreas. Left-sided resection, lower third of œsophagus, total gastrectomy, splenectomy, hemipancreatectomy, œsophago-jejunostomy.

This patient stood the operation remarkably well, but regurgitated milk into the trachea and died of bronchopneumonia 2 days after operation. Fat found in pulmonary alveoli.

Case 4 (Oct. 30, 1944).—G. C., male aged 71, 6 weeks' history. Mid-œsophageal carcinoma. Right-sided resection, Kirschner-Taylor extrathoracic anastomosis.

Died 3 days later of acute dilatation of the stomach, unrelieved by aspiration. This patient was too old to stand more than resection with exteriorization. The anastomosis should have been left to a second stage.

b. Recoveries from Operation.—

Case 5.—G. F., female aged 51, 2 months' history, able to swallow fluids only. Carcinoma of lower end of œsophagus.

Feb. 1, 1943: Gastrostomy.

Feb. 16: Left-sided resection, cardia closed, anastomosis to fundus. Spleen removed. Water-sealed drain to pleura.

Gastrostomy tube out and swallowing normally in 14 days, full meals in 3 weeks. Convalescence impeded by loculated empyema, drained 1 month after operation.

Pathological Report: An ulcer 1 in. × 2 in. in the lower end of the œsophagus involving the cardia. One gland from the lesser curvature contains growth. Microscopical section—squamous epithelioma.

This patient survived 7 months and died presumably of a recurrence. No post-mortem obtainable.

Case 6.—W. W., male aged 72, 6 weeks' history, still able to swallow minced solids. Carcinoma lower end of œsophagus.

Feb. 21, 1944: Left-sided resection, cardia closed, anastomosis to fundus. Spleen not removed. No pleural drainage. This was a long growth extending nearly as far as the arch of the aorta, and anastomosis was correspondingly difficult.

Swallowed water at 48 hours, Meulengracht diet in 10 days, full meals at 3 weeks. This patient was hardly upset at all by the operation. At 6 months he had some return of dysphagia which yielded to dilatation with a mercury bougie. When seen at 1 year was swallowing normally and feeling quite well. Had not used his bougie for 6 months. Still alive and well (1 year and 8 months).

Pathological Report: An ulcer 3 in. × 2 in. in the lower end of the œsophagus. Cardia not involved. Microscopical section—squamous epithelioma (*Fig.* 192).

Case 7.—K. P., female aged 48, 5 months' history, still able to swallow minced solids. Carcinoma, lower end of œsophagus.

This patient was a very heavy smoker with a persistent cough and bronchitis, and operation had to be postponed for three months until her chest condition cleared up.

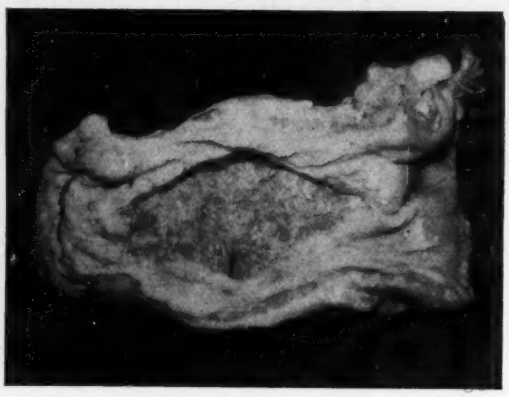

FIG. 192.—Photograph showing ulcer in lower end of resected cardia.

Oct. 30, 1944: Left-sided resection and anastomosis. The growth had extended for 2 in. into the stomach, necessitating resection of the upper third of that viscus, together with the spleen. The œsophagus was anastomosed to the cut end of the stomach. No pleural drainage. Meulengracht diet in 10 days, swallowing full meals at 3 weeks.

This patient developed a stinking localized empyema which cleared up with rib resection. The infection was a mixed one, with some of the organisms penicillin-sensitive, but systemic and local exhibition of penicillin in full doses did not appear to affect the course of the empyema. When seen at 6 months was quite well and swallowing normally. Still alive and well (1 year).

Pathological Report: An ulcer involving the lower ½ in. of the œsophagus and 2 in. of the fundus of the stomach. Microscopical section—squamous epithelioma.

Case 8.—P. H., male aged 46.

History: 1928, perforated gastric ulcer; 1932, perforated duodenal ulcer; 1938, gastrocolic fistula.

The operative treatment of these conditions had been carried out elsewhere, and he arrived with another gastrocolic fistula, for which I performed a subtotal gastrectomy on Nov. 22, 1943. He reappeared 10 months later with a jejunal ulcer, and it was obvious that nothing short of a total gastrectomy would discourage the ulcerous enthusiasm of his stomach.

Sept. 24, 1944: In view of the massive adhesions in his abdomen it was decided to remove what remained of his stomach transpleurally. It was remarkable how easy by this approach was the undoing of the anastomosis, reconstitution of the jejunum, resection of the stomach, and œsophago-jejunostomy. The spleen was not removed nor was the pleura drained, and the patient was less upset by the operation than a man in the next bed who had a straightforward partial gastrectomy for ulcer on the same day.

He has had no trouble with swallowing or fullness after meals, and his blood-count is being checked at regular intervals. Alive and well 1 year after operation.

DISCUSSION

1. Preliminaries.—The diagnosis must be established with certainty by X-ray examination, œsophagoscopy, and biopsy. If the patient has been starved by his obstruction it is necessary to make him as fit as possible for his ordeal. If he is fortunate it will occasionally be found that he can still swallow fairly well, in which case it is only necessary to put him on a high protein diet and correct any anæmia by blood transfusion. Gastrostomy or jejunostomy may be required, but as gastrostomy may interfere with the subsequent manœuvres by tethering the stomach it is preferable if possible to dilate the stricture with Plummer's bougies. If gastrostomy is performed it is an advantage to pull the stomach as far over to the left as possible and insert the catheter near the pylorus, leaving the fundus and body free. Pre-operative induction of pneumothorax is unnecessary. A blood-drip during operation is essential.

2. Approach.—The lower œsophagus and fundus of the stomach are more easily accessible from the left side, the mid-œsophagus from the right. Indeed, the whole of the œsophagus is more easily exposed from the right, the easily-disposable vena azygos being the only intervening structure, but on this side the approach to the abdomen is hindered by the liver. It is possible, however, after opening the right side of the diaphragm, to divide the falciform and coronary ligaments of the liver and rotate the liver temporarily up into the chest, thus facilitating the intra-abdominal manipulations.

Owing to the extreme obliquity of the thoracic inlet, growths in or extending into the upper part of the thoracic œsophagus are much nearer the cricoid than would appear on thoracotomy, with the result that after adequate resection the remaining stump of œsophagus would be too short to permit of reasonably easy anastomosis, or even exteriorization. Such tumours should at present be regarded as inoperable.

3. Choice of Anæsthetic.—Cyclopropane is used extensively in thoracic surgery, but in the capable hands of my anæsthetic colleague avertin, followed by gas and oxygen, with the addition of a little chloroform from time to time to damp down any tendency to excessive respiratory movements, has given a beautifully smooth anæsthesia.

4. Incision.—A long intercostal incision has been used in all these cases, extending from the costal cartilage in front to the transverse process behind, cutting across the erector spinæ. Division of the neck of the rib above and below allows of wider retraction; injection of proctocaine or removal of a segment of rib to avoid after-pain has proved unnecessary. The space used depends on the situation of the growth; the 7th permits easier access to the region of the arch of the aorta, the 9th to the far side of the abdomen. If more room is required in an upward direction the necks of one or two ribs, together with the intercostal structures, can be divided, and hæmorrhage can be controlled by passing a ligature around rib and vessels.

5. Approach to the Mediastinum.—The lung will frequently be found adhering to the parietal pleura, particularly in the paravertebral gutter. Division of the adhesions and the ligamentum latum pulmonis up as far as the inferior pulmonary vein gives adequate exposure. The œsophagus is less intimately connected with the left pleura than it is with the right; incision of the former is usually all that is required to explore the growth and the

mediastinum, whereas a segment of pleura together with vena azygos may have to be removed on the right side.

Care must be taken while freeing the growth to avoid tearing the opposite pleura, although with positive pressure anæsthesia this accident is of little moment as the lung can be kept working till the rent is repaired. In mid-œsophageal growths the left pleura is kept out of harm's way by the aorta, but the lower medial angle of the right pleura comes surprisingly far over to the left and is easily torn unless this point is remembered (Grey Turner, 1936).

6. Approach to the Abdomen.—After crushing the phrenic nerve the diaphragm is incised radially from the œsophageal hiatus. The hiatus itself may be involved in the growth and a segment excised. The division of the medial part of the diaphragm is facilitated by using a finger passed through the hiatus from below as a retractor. The abdomen is explored, particularly the fundus of the stomach, the liver, and the cœliac and lesser curvature glands. If at this stage the condition is found to be inoperable the diaphragm and chest can be closed with as little after-effects as from an exploratory laparotomy, and probably less; certainly there is no risk of a burst abdomen!

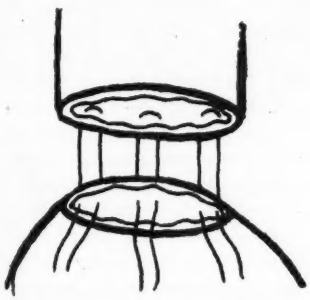

FIG. 193.—Interrupted through-and-through sutures in outer layer of anastomosis.

7. Removal of the Growth.—The œsophagus is mobilized above the growth and a gauze retractor passed round it. The growth itself is then freed, but if this proves at all difficult it may be easier to mobilize the stomach first and then the growth. Dissection in the region of the arch of the aorta does not appear to cause undue upset when carried out from the right side, but any tunnelling behind the aorta in the course of a left-sided exposure is liable to provoke hostile comments from the anæsthetist watching the pulse and blood-pressure. It is immaterial whether the spleen is removed with the stomach or not; the decision rests entirely on which course is easier. The greater curvature of the stomach is freed and the lesser omentum divided; the greater omentum is removed if the stomach is widely involved. The coronary vessels are ligatured as near the cœliac axis as possible, and the glands along the lesser curvature are stripped upwards towards the cardia. That this is a most important step in the operation is shown by the figures of Churchill and Sweet (1942, b), demonstrating that 50 per cent of growths of the lower œsophagus, and even 30 per cent of mid-œsophageal growths, metastasize below the diaphragm.

The œsophagus and stomach are then cut across well above and below the growth. The stomach can quite easily be cleared as far as the pylorus; in fact, the peritoneum on the right side of the duodenum can be divided so as to mobilize it still further, and the extent to which intra-abdominal manipulations are possible is shown by *Case* 8. The right gastro-epiploic artery carries ample blood to nourish any stomach which may be left, but no fears need be entertained for the viability of this very vascular viscus. Hey's ligature operation for duodenal ulcer involves tying every possible artery supplying the stomach which then depends solely on vessels reaching it via the walls of the duodenum and œsophagus, yet I have never seen any harm come to the stomach following its performance.

8. The Anastomosis.—A direct primary anastomosis is the most desirable course, and in growths of the lower œsophagus and stomach this is generally feasible. The fundus of the stomach can be pulled much farther up into the chest than the cardia, so the simplest plan is to close the cardia and anastomose the cut end of the œsophagus to a fresh opening in the fundus, as suggested by Ogilvie (1938). There are many ways of doing this, but in my hands Grey Turner's interrupted through-and-through mattress sutures anteriorly and posteriorly (*Fig.* 193) have provided a firm outer layer supporting a continuous through-and-through inner suture (*Fig.* 194). If the anterior part of this continuous suture inverts rather than everts the apposed surfaces, it will be found that the fourth layer will bury it neatly with greater ease.

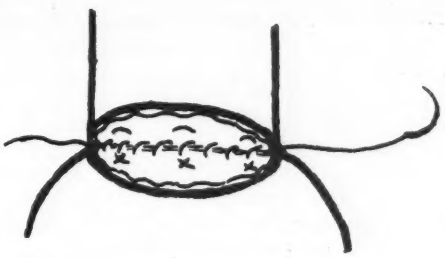

FIG. 194.—Continuous through-and-through inner suture.

With regard to the œsophagus as material for suturing, the following experiment was carried out in order to determine its tensile strength relative to that of the stomach. An œsophagus was removed from a body within 6 hours of death and a stitch passed through all its coats approximately ¼ in. from the cut end. Lead shot was poured into a tin suspended from the stitch until it cut out, when the tin with its contents was weighed. The mean of six such attempts was taken and the average weight found to be 2¼ lb. with a variation of ¼ lb. either way. A similar series of stitches was taken through all coats of the stomach from the same subject, when the mean cutting-out weight proved to be 4¼ lb. The bite of the stitches was measured by eye so as to conform to conditions in actual practice. This shows that, provided a good bite is taken of all coats, the œsophagus will stand nearly half as much tension as the strong stomach, which is surprising

in view of the friability of the œsophageal muscle and the absence of a peritoneal coat.

If the stomach is cut across below the growth it may still be possible to perform an œsophago-gastrostomy, but the technical difficulties of apposing a short to a long stoma are greater. If much stomach has to be removed it will be found easier to close the lower end and bring the jejunum up instead. The jejunal mesentery may be long enough to allow it to come up without tension, but if it is short it will have to be mobilized in the manner described by Yudin (1944). The main vessels supplying the jejunal arcades are completely cleared of peritoneum and tied as near the superior mesenteric as possible; the arteries are tied separately from the veins. If these precautions are not taken the ligatures tend to slip off when the gut is put on the stretch. The vigorous peristalsis which follows division of the vessels is most striking and is a great nuisance in that it forces the mucosa out of the jejunal stoma, interfering with the performance of the anastomosis. An end-to-side œsophago-jejunostomy similar to that described for the fundus of the stomach is perfectly satisfactory, but the method of Roscoe Graham (1940) may be used. In this the jejunum is attached to the back of the œsophagus above the cut end (*Fig.* 195), and after the anastomosis has been made the proximal jejunal loop is wrapped and stitched over the front of the anastomosis so as to include it between two peritoneal surfaces (*Fig.* 196).

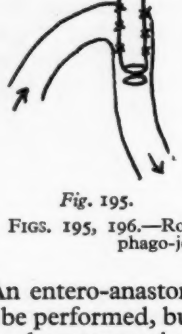

Fig. 195.

Fig. 196.

FIGS. 195, 196.—Roscoe Graham's method of œsophago-jejunostomy (*see text*).

An entero-anastomosis between the jejunal loops may be performed, but is unnecessary with a straightforward anastomosis.

9. Closure.—The diaphragm is closed around the viscus herniated into the chest and the rest of the closure completed in the usual way.

10. Drainage.—It does not seem to matter much whether the pleura is drained or not. It would seem advantageous not to leave a collection of blood as a nidus for infection, but of the cases which recovered the one which was drained developed an empyema whereas only one of the three which were not drained did so.

11. Duration of Operation.—The shortest time for the complete operation in this series has been 1 hour 40 minutes, the longest 3 hours. If the patient is over 60 he will begin to flag after 2 hours.

12. After-treatment.—Continuous gastric or intestinal suction combined with rectal or intravenous drip (taking care with the latter not to waterlog the lungs) combats distension and dehydration and yet allows the uplift to morale of occasional sips of water. Feeding by mouth can be commenced quite early and can be gradually increased. The B.L.B. mask has been used to combat anoxæmia, but although good in principle its practical value has been doubtful.

13. Complications.—

a. Shock.—Many patients will die in the first 24–48 hours, and nothing will save them.

b. Collapse of the Lung.—The lung collapsed at operation will expand as the water-sealed drain comes into play, or it can be blown out before closure of the chest and will usually stay expanded. More serious is collapse due to blockage of the bronchus, which may necessitate early passage of the bronchoscope; mucus may be found and sucked out, but possibly the forcible coughing which usually accompanies introduction of the instrument does just as much good. Collapse of the opposite lung is an even more disappointing complication.

c. Œdema of the Lungs.—Too much intravenous saline may be responsible, but even when this has not been administered œdema is liable to develop at both bases and nothing will check it.

d. Empyema.—Infection of the pleura might be expected in every case, but even with the most septic growths it does not necessarily supervene. Small effusions will probably be absorbed, while if larger they may be aspirated or drained.

e. Leakage of the Anastomosis.—This has not been encountered in the present series. Either leakage has not occurred or the patient has died before it could take place.

f. Stenosis of the Anastomosis.—One of the four survivors developed dysphagia, which was relieved by the passage of a mercury bougie.

From the foregoing it may be concluded that if a patient is not too feeble and does not harbour too advanced a growth; if he survives the operative onslaught; if he does not die of collapse or œdema of the lungs in the first 48 hours; and if he negotiates successfully the hazards of an empyema; he will at least swallow in comfort for the rest of his life and stand a sporting chance of prolonging his existence.

I am indebted to Mr. W. H. Ogilvie for his literary criticism of this report; and no worker in this field can omit a record of his indebtedness to the pioneer work of Grey Turner.

REFERENCES

CHURCHILL, E. D., and SWEET, R. H. (1942, a), *Ann. Surg.*, **115**, 897.
— — — — (1942, b), *Ibid.*, **116**, 566.
GRAHAM, R. R. (1940), *Surgery*, **8**, 257.
KIRSCHNER (1920), *Arch. klin. Chir.*, **114**, 60.
OGILVIE, W. H. (1938), *Brit. J. Surg.*, **26**, 10.
TAYLOR, H. (1945), *Ibid.*, **127**, 394.
THOMPSON, V. C. (1945), *Ibid.*, **127**, 377.
TURNER, G. GREY (1936), *Lancet*, **1**, 67.
YUDIN, S. S. (1944), *Surg. Gynec. Obstet.*, **6**, 561.

PENICILLIN TREATMENT OF ACUTE HÆMATOGENOUS OSTEOMYELITIS

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ACUTE osteomyelitis provides an excellent ground for testing the efficacy of new bacteriostatic or bactericidal drugs. Their value in this disease must be assessed by measuring the extent to which they fulfil the two principal aims of treatment: first, the saving of life by overcoming the initial septicæmia or pyæmia; and secondly, the cutting short of local infection and the limiting of bone necrosis. In this paper, penicillin treatment of 40 patients will be discussed from both standpoints, except that assessment of the state of the local bone lesion is limited to 32 cases in which long bones were affected.

METHODS OF TREATMENT AND CLINICAL COURSE

Administration of Penicillin.—All patients have been treated in the wards of the Royal Infirmary and the Royal Hospital for Sick Children, Edinburgh. A daily dose of 100,000 units of penicillin has been used, although some patients with septicæmia received a daily dose of 200,000 units until there was evidence that the septicæmia had been controlled. The daily dose was given in 100 c.c. of sterile normal saline and the 'Eudrip 3' apparatus for continuous infusion was found to be the most convenient method of administration. The solution was given either intramuscularly (29 cases) or through an intramedullary needle* (11 cases); the small volume of the daily dose made the latter route possible even in very young children, over a period of 21 days. Both methods have been found effective; the intramuscular route is more easily supervised by the nursing staff, although the site of infusion must be changed every second day, whereas by the intramedullary route it has been possible to maintain infusion for 21 days without changing the position of the needle. The aim of intramedullary administration is to provide a high concentration of penicillin locally and at the same time to secure sufficient absorption into the bloodstream to control general infection.

Approximate estimation of the level of penicillin in serum (or pus) was made by a method which has been used in the Bacteriology Department of Edinburgh University, and which will be described fully elsewhere. This method may be outlined as follows: The serum (or pus filtrate) is serially diluted with *nutrient broth* and inoculated with a standard loopful of a diluted culture of the Oxford strain of *Staph. aureus*. After incubation, the tubes are examined for growth and the highest dilution in which no growth has occurred is noted. Partial stasis may also be observed and interpretation of the results is facilitated and confirmed by subsequent plating on blood-agar from each dilution.

Some of the results are recorded in the following tables.

As all patients received 100,000 units of penicillin a day, irrespective of their age, it is not surprising to find a wide variation in the serum bacteriostatic level (*Table I*). Failure to maintain a uniform rate of intramedullary administration in the first few days of treatment resulted in 3 serum specimens showing no bacteriostasis (*Table I*).

From the above tables it will be seen that intramuscular infusion produces almost the same range of serum bacteriostatic levels as intramedullary, but a lower concentration of penicillin in the pus.

For the effective treatment of an infection with penicillin, it is still uncertain what bacteriostatic level should be maintained in the patient's serum: it would appear to depend on many factors, but not least on whether the infection was general (septicæmia) or local (abscess). The serum bacteriostatic level required in treating a septicæmia presumably varies with the penicillin sensitivity of the infecting organism, while the determining factor in a localized infection is the permeability of the wall of the cavity to the passage of penicillin.

At first it was thought that for a general infection penicillin administration should aim at producing

Table I.—SERUM BACTERIOSTATIC LEVELS OBTAINED DURING THE ADMINISTRATION OF 100,000 UNITS OF PENICILLIN PER DAY

	Number of Serum Specimens	
	Intramedullary Administration	*Intramuscular Administration*
No stasis in undiluted serum	3	—
Partial stasis in undiluted serum	3	2
Complete stasis in undiluted serum	9	8
" " " serum diluted 1–2	14	12
" " " " " 1–4	2	5
" " " " " 1–8	2	4
Total	33	31

Table II.—BACTERIOSTASIS IN INTRAMEDULLARY PUS DURING ADMINISTRATION OF 100,000 UNITS OF PENICILLIN PER DAY

	Number of Specimens of Pus	
	Intramuscular	*Intramedullary**
Partial stasis in undiluted pus	1	—
Complete stasis in undiluted pus	4	—
" " " pus diluted 1–2	4	—
" " " " " 1–1000 or higher	—	8
Total	9	8

* Pus specimens taken from intramedullary needle at site of infusion.

* Intramedullary infusion is carried out through a sternal puncture needle inserted into the metaphysis of the infected bone.

complete bacteriostasis in serum when diluted 1–2, but in this series recovery from staphylococcal septicæmia has been possible when the patient's serum showed complete stasis in undiluted serum only. *Table II* shows that after intramuscular administration (100,000 units per day) penicillin passes freely into the pus of the local bone lesion.

The intramedullary method appears particularly suitable where the infected metaphysis is intracapsular (neck of femur) and there is an almost inevitable septic arthritis. In view of the successful results obtained by this method, it would appear that in such cases a route is open for the passage of penicillin from metaphysial focus to infected joint cavity.

The introduction of a needle into the medulla of an infected bone can also be used for purposes other than administration of penicillin. First, during its insertion it allows of aspiration of a subperiosteal abscess, and when introduced further, through the cortex, it relieves intramedullary tension (*Fig.* 197). Secondly, by aspiration of pus a precise

FIG. 197.—Intramedullary decompression: drainage through an intramedullary needle. In this case 90 c.c. of infected fluid were drained in the first three days.

bacteriological diagnosis can be made, and later the time of clearance of organisms from the marrow accurately determined. These clearance times (sterilization times) are of the utmost importance in deciding the duration of treatment. *Table III* shows that in 18 patients the average clearance time for staphylococcal infections was 14 days. In most patients treatment was continued until three successive daily specimens of pus proved to be sterile. Temperature chart and leucocyte-count were found unreliable as guides to the severity of local infection. Our observations of clearance times support the practice in staphylococcal infections of continuing treatment for not less than 14 days; the single proved hæmolytic streptococcal infection responded more rapidly.

General Response to Penicillin Treatment.—There are two well-defined clinical types of osteomyelitis, and the response to penicillin treatment supports this classification. The first group includes patients with evidence of septicæmia in addition to a local lesion of bone; the second group comprises those with a local lesion only. Of our 40 patients, 21 had a generalized infection, 10 had metastatic foci and 20 had positive blood-cultures. The clinical response in these patients was not dramatic. They remained critically ill for 3–7 days, and often there was little encouragement to be gained from the temperature chart. Improvement in general well-being was usually the first reliable indication that treatment was proving effective. The blood-cultures

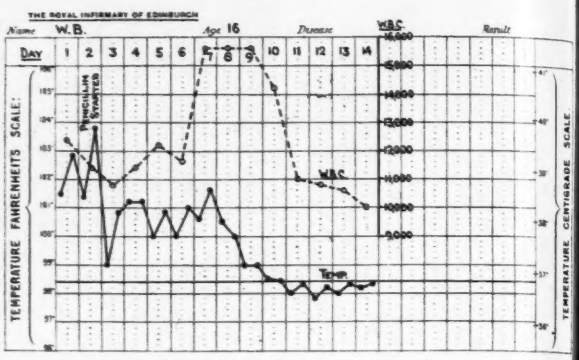


FIG. 198.—*Case* 25. Temperature chart and leucocyte response of patient with a septicæmia (first clinical type).

became sterile, on an average in 3 days, whereas the temperature remained raised for 7–14 days, finally settling by lysis. The leucocyte-count usually paralleled the fall in temperature, but occasionally, when low at the start of treatment, it was observed to rise while the general infection was being controlled. This should not be interpreted as indicating a further spread of infection, but rather as a favourable prognostic sign (*Fig.* 198).

Table III shows that 10 of the 21 patients in this group had metastatic lesions on admission to hospital. There were 6 staphylococcal pneumonias, 2 soft-tissue abscesses, 2 metastases to other bones, and 1 septic pericarditis. The soft-tissue abscesses were drained and healed rapidly; the pneumonias were controlled within 7 days; and the patient with a septic pericarditis was treated by aspiration and local instillation of penicillin, which sterilized the pericardial effusion in 9 days.

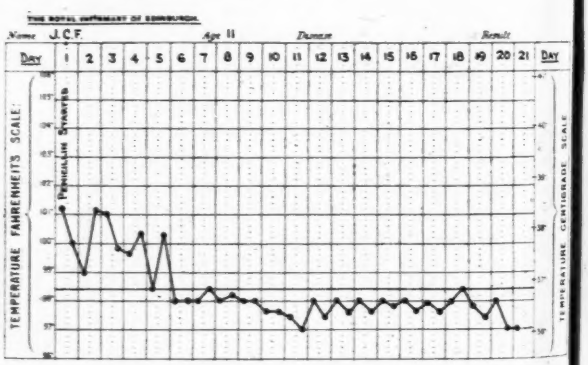


FIG. 199.—*Case* 21. Temperature chart of patient with local bone lesion only (second clinical type).

The second clinical type includes 19 patients with a varying degree of toxæmia in whom the general condition was good, the blood-cultures were negative and there were no metastatic lesions. The temperature usually subsided within 7 days of the start of treatment, and general improvement was obvious before this time (*Fig.* 199).

Table III.—Details of Treatment of Acute Hæmatogenous Osteomyelitis

Case No.	Age (Yr.)	Primary Site	Metastatic Lesions	Start of Treatment (Day)	Blood-culture	Marrow Culture	Clearance Times (Days)		Surgical Treatment	Route	Duration (Days)		Complications	Functional Result	Radiological Appearances
							Blood	*Marrow*			*Penicillin Treatment*	*Hospitalization*			
A. Acute Osteomyelitis of Long Bones, treated Conservatively.—															
1	6	Neck of femur	None	14th	Sterile	*Staph. aureus*	—	8	Intramedullary aspiration. Immobilization	Intramedullary	21	42	Septic arthritis	Ankylosis of hip-joint. Immobilization 28 wk. Not walking after 32 wk.	At 32 wk., stage of advanced recalcification. Hip-joint obliterated
2	9	Neck of femur	None	10th	Sterile	*Staph. aureus*	—	10	Intramedullary aspiration. Immobilization	Intramedullary	11	28	Septic arthritis	Walking 12 wk. Complete movements of hip-joint	At 14 wk., stage of recalcification. Joint normal
3	5	Neck and shaft of femur	None	10th	*Staph. aureus*	—	1	—	Immobilization	Intramuscular	10	21	Septic arthritis	Not walking after 11 wk. Complete movement of hip-joint	At 11 wk., stage of decalcification. Neck and whole shaft involved. Joint normal
4	8	Neck of femur	None	5th	Sterile	*Staph. aureus*	—	10	Intramedullary aspiration. Immobilization	Intramedullary	14	21	None	Immobilization discontinued. Not walking after 8 wk. Hip movements present	At 8 wk., stage of decalcification. Joint normal
5	15	Upper shaft of femur	Acromioclavicular joint	9th	Sterile	*Staph. aureus*	—	14	Intramedullary aspiration. Immobilization	Intramuscular	21	35	None	Walking 18 wk. Work 26 wk. Complete movements	At 32 wk., stage of 'healed' lesion. Whole shaft involved
6	16	Upper shaft of femur	None	8th	Sterile	*Staph. aureus*	—	9	Intramedullary aspiration. Immobilization	Intramuscular	13	21	None	Walking 9 wk. Full movements	At 16 wk., stage of recalcification. Upper ⅓ shaft involved
7	17	Upper shaft of femur	None	6th	Sterile	—	—	—	Immobilization	Intramuscular	14	42	None	At 8 wk., walking and hip movements almost complete	At 10 wk., stage of recalcification
8	9	Lower femur	None	4th	Sterile	*Staph. aureus*	—	20	Intramedullary aspiration. Immobilization	Intramedullary	21	42	None	Not walking after 9 wk.	At 10 wk., stage of recalcification. Lower ⅓ of shaft involved. Small sequestrum present
9	16	Lower femur	None	4th	Sterile	—	—	—	Immobilization	Intramuscular	21	56	None	Walking 9 wk. Work 12 wk. Complete movements	At 24 wk., stage of 'healed' lesion. Lower ⅓ femur involved
10	12	Lower femur	Radius	5th	*Staph. aureus*	—	4	—	Immobilization	Intramuscular	14	28	None	Walking 12 wk. Complete movements	At 32 wk., stage of 'healed' lesion. Lower ⅓ femur involved
11	8	Lower femur	None	5th	Sterile	*Staph. aureus*	—	15	Intramedullary aspiration. Immobilization	Intramedullary	16	28	None	Not walking after 12 wk.	At 12 wk., stage of recalcification. Lower ⅓ femur involved
12	16	Lower femur	None	5th	*Staph. aureus*	—	—	—	Immobilization	Intramuscular	15	21	None	Still immobilized after 4 wk.	At 4 wk., stage of decalcification
13	15	Lower femur	None	5th	Sterile	*Staph. aureus*	—	8	Immobilization	Intramuscular	17	49	None	Immobilization discontinued. Not walking after 16 wk.	At 16 wk., stage of recalcification. Lower ⅓ femur involved. Small sequestra
14	9	Upper tibia	None	5th	*Staph. aureus*	*Staph. aureus*	3	15	Subperiosteal and intramedullary aspiration. Immobilization	Intramedullary	11	24	None	Walking 6 wk. School 12 wk. Complete movements	At 24 wk., stage of 'healed' lesion. Upper ⅓ shaft involved
15	16	Upper tibia	None	7th	*Staph. aureus*	*Staph. aureus*	5	8	Intramedullary aspiration. Immobilization	Intramedullary	10	28	None	Not walking after 16 wk.	At 16 wk., stage of recalcification. Bipolar lesion
16	8	Upper tibia	None	4th	Sterile	*Staph. aureus*	—	14	Subperiosteal and intramedullary aspiration. Immobilization	Intramedullary	17	24	None	Walking 5 wk. School 8 wk.	At 10 wk., stage of recalcification. Upper ⅓ shaft involved. Small sequestrum
17	9	Lower tibia	None	4th	Sterile	*Staph. aureus*	—	12	Intramedullary aspiration. Immobilization	Intramedullary	21	31	None	Walking 12 wk. School 20 wk. Complete movements	At 40 wk., stage of 'healed' lesion. Lower ⅓ shaft involved
18	9	Lower tibia	Lungs	12th	Sterile	*Staph. aureus*	—	21	Intramedullary aspiration. Immobilization	Intramedullary	23	56	Septic arthritis ankle	Walking 24 wk. School 28 wk. Limited ankle movements	At 60 wk., stage of 'healed' lesion. Lower ⅓ shaft involved. Joint space narrowed
19	3	Lower tibia	None	6th	*Staph. aureus*	*Staph. aureus*	3	13	Subperiosteal and intramedullary aspiration. Immobilization	Intramedullary	16	49	None	Not walking after 5 wk. Complete movements	At 5 wk., stage of decalcification. ⅓ shaft involved
20	13	Lower tibia	None	5th	*Staph. aureus*	*Staph. aureus*	3	20	Intramedullary aspiration. Immobilization	Intramuscular	23	30	None	Still immobilized at 5 wk.	At 5 wk., stage of decalcification. ⅓ shaft involved
21	11	Lower tibia	None	5th	Sterile	*Staph. aureus*	—	—	Subperiosteal aspiration. Immobilization	Intramuscular	15	21	None	Walking 6 wk. School 9 wk.	At 28 wk., stage of 'healed' lesion. Lower ⅓ shaft involved
													Sinus pre-	Still in hospital after 4	

9	10	Lower femur	None	4th	Sterile				Immobilization	cular	21	30	None	12 wk. Complete movements	' healed ' lesion. Lower ⅓ femur involved
10	12	Lower femur	Radius	5th	*Staph. aureus*	—	4	—	Immobilization	Intramus-cular	14	28	None	Walking 12 wk. Complete movements	At 32 wk., stage of ' healed ' lesion. Lower ⅓ femur involved
11	8	Lower femur	None	5th	Sterile	*Staph. aureus*	—	15	Intramedullary aspiration. Immobilization	Intrame-dullary	16	28	None	Not walking after 12 wk.	At 12 wk., stage of recalcification. Lower ⅓ femur involved
12	16	Lower femur	None	5th	*Staph. aureus*	—	—	—	Immobilization	Intramus-cular	15	21	None	Still immobilized after 4 wk.	At 4 wk., stage of decalcification
13	15	Lower femur	None	5th	Sterile	*Staph. aureus*	—	8	Immobilization	Intramus-cular	17	49	None	Immobilization discontinued. Not walking after 16 wk.	At 16 wk., stage of recalcification. Lower ⅓ femur involved. Small sequestra
14	9	Upper tibia	None	5th	*Staph. aureus*	*Staph. aureus*	3	15	Subperiosteal and intramedullary aspiration. Immobilization	Intrame-dullary	11	24	None	Walking 6 wk. School 12 wk. Complete movements	At 24 wk., stage of ' healed ' lesion. Upper ⅓ shaft involved
15	16	Upper tibia	None	7th	*Staph. aureus*	*Staph. aureus*	5	8	Intramedullary aspiration. Immobilization	Intrame-dullary	10	28	None	Not walking after 16 wk.	At 16 wk., stage of recalcification. Bipolar lesion
16	8	Upper tibia	None	4th	Sterile	*Staph. aureus*	—	14	Subperiosteal and intramedullary aspiration. Immobilization	Intrame-dullary	17	24	None	Walking 5 wk. School 8 wk.	At 10 wk., stage of recalcification. Upper ⅓ shaft involved. Small sequestrum
17	9	Lower tibia	None	4th	Sterile	*Staph. aureus*	—	12	Intramedullary aspiration. Immobilization	Intrame-dullary	21	31	None	Walking 12 wk. School 20 wk. Complete movements	At 40 wk., stage of ' healed ' lesion. Lower ⅓ shaft involved
18	9	Lower tibia	Lungs	12th	Sterile	*Staph. aureus*	—	21	Intramedullary aspiration. Immobilization	Intrame-dullary	23	56	Septic arthritis ankle	Walking 24 wk. School 28 wk. Limited ankle movements	At 60 wk., stage of ' healed ' lesion. Lower ⅓ shaft involved. Joint space narrowed
19	3	Lower tibia	None	6th	*Staph. aureus*	*Staph. aureus*	3	13	Subperiosteal and intramedullary aspiration. Immobilization	Intrame-dullary	16	49	None	Not walking after 5 wk. Complete movements	At 5 wk., stage of decalcification. ⅓ shaft involved
20	13	Lower tibia	None	5th	*Staph. aureus*	*Staph. aureus*	3	20	Intramedullary aspiration. Immobilization	Intramus-cular	23	30	None	Still immobilized at 5 wk.	At 5 wk., stage of decalcification. ⅓ shaft involved
21	11	Lower tibia	None	5th	Sterile	*Staph. aureus*	—	—	Subperiosteal aspiration. Immobilization	Intramus-cular	15	21	None	Walking 6 wk. School 9 wk.	At 28 wk., stage of ' healed ' lesion. Lower ⅓ shaft involved

					aureus	*aureus*			tion. Immobilization	cular					cification. ¼ shaft involved
21	11	Lower tibia	None	5th	Sterile	*Staph. aureus*	—	—	Subperiosteal aspiration. Immobilization	Intramuscular	15	21	None	Walking 6 wk. School 9 wk.	At 28 wk., stage of 'healed' lesion. Lower ¼ shaft involved
22	13	Lower tibia	Lungs	8th	*Staph. aureus*	*Staph. aureus*	1	—	Immobilization	Intramuscular	15	—	Sinus present on admission	Still in hospital after 4 wk. Sinus healed	
23	13	Lower tibia	None	4th	Sterile	*Staph. aureus*	—	—	Intramedullary aspiration. Immobilization	Intramuscular	—	—	None	Still in hospital after 10 days.	
24	15	Upper humerus	None	7th	*Staph. aureus*	—	4	—	Immobilization	Intramuscular	10	28	Septic arthritis of shoulder	Complete movements 8 wk. Work 16 wk.	At 20 wk., stage of recalcification. Whole shaft involved. Small sequestra. Joint normal
25	16	Upper humerus	None	7th	*Staph. aureus*	—	3	—	—	Intramuscular	14	42	None	Complete movements 3 wk. Work 6 wk.	At 12 wk., stage of recalcification. ¾ shaft involved. Small sequestra
26	10	Upper humerus	None	6th	Sterile	—	—	—	—	Intramuscular	16	42	Pathological fracture	Still immobilized 2 wk. after pathological fracture	At 6 wk., stage of decalcification
27	13	Radius	None	14th	Sterile	*Staph. aureus*	—	—	Subperiosteal aspiration. Immobilization	Intramuscular	—	—	None	Still in hospital after 10 days.	
B. Acute Osteomyelitis of Long Bones, treated by Incision of Abscess ± Bone Drilling.—															
28	11	Upper tibia	Lungs	5th	*Staph. aureus*	*Staph. aureus*	5	42+	Incision of abscess and bone drilling. Immobilization	Intramuscular	21	42	—	Died	
29	9	Upper tibia	Lungs	3rd	*Staph. aureus*	*Staph. aureus*	4	16	Incision of abscess and bone drilling. Immobilization	Intramuscular	16	112	Sinus	At 28 wk., in walking plaster	Large sequestrum present
30	11	Lower tibia	Radius	3rd	*Staph. aureus*	*Staph. aureus*	5	—	Incision of abscess and bone drilling. Immobilization	Intramuscular	14	21	Septic arthritis of ankle	Walking 20 wk. School 32 wk. Limited ankle movements	At 32 wk., stage of 'healed' lesion. ¼ shaft involved
31	14	Lower tibia	Pericardium, elbow, acromioclavicular joint	7th	*Staph. aureus*	*Staph. aureus*	2	21	Incision of abscess. Immobilization	Intramuscular	28	77	Sinus. Septic arthritis of ankle	Walking 32 wk. Work 44 wk. Limited ankle movements	Large sequestra present at 30 wk. Stage of 'healed' lesion 28 wk. after sequestrectomy. Joint space narrowed
32	30	Lower tibia	None	13th	*Staph. aureus*	*Staph. aureus*	3	—	Incision of abscess. Immobilization	Intramuscular	16	—	None	Still in hospital after 5 wk.	At 5 wk., stage of decalcification. Small sequestra present
C. Acute Osteomyelitis of Other Bones.—															
33	15	Ilium	None	10th	*Staph. aureus*	—	3	—	—	Intramuscular	14	21	None	Walking at 4 wk.	
34	13	Ilium	None	1st	*Staph. aureus*	—	2	—	Immobilization	Intramuscular	18	49	Septic arthritis of hip	Complete destruction of joint. Still in plaster after 14 wk.	
35	20	Ilium	Lungs	4th	*Staph. aureus*	—	4	—	—	Intramuscular	16	25	None	Walking after 4 wk.	
36	38	Pelvis	Lungs	12th	*Staph. aureus*	—	1	—	—	Intramuscular	12	42	Septic arthritis of hip	Complete destruction of joint	
37	10	Tarsus	None	5th	Sterile	*Staph. aureus*	—	—	Immobilization	Intramuscular	19	28	Septic arthritis of ankle	Limitation of ankle movements	
38	12	Tarsus	None	3rd	Hæm. streptococcus	—	—	—	Immobilization	Intramuscular	10	21	None	Walking after 5 wk.	
39	13	Tarsus	None	5th	Sterile	—	—	—	Immobilization	Intramuscular	14	28	None	Still in plaster after 4 wk.	
40	19	Zygoma	None	7th	Sterile	*Staph. aureus*	—	—	Incision of abscess	Intramuscular	8	28	None	Wound healed after 3 wk.	

Case No.	Age (Yr.)	Bone Affected	Organism Found	Blood Culture	Duration of Symptoms before Admission (Days)	Operative Findings—Macroscopic Appearances					Microscopic Appearances					Subsequent Treatment	Result
						Site	Pus	Bone Destruction	Involvement of Epiphysis	Involvement of Joint	Site	Pus	Bone Destruction	Involvement of Epiphysis	Involvement of Joint		
1	0	Upper end of femur	None	Staph. albus	14th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
2	0	Neck of femur	None	Staph. albus	10th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
3	5	Neck and head of femur	None	Staph. albus	10th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
4	8	Neck of femur	None	Staph. albus	10th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
5	13	Upper end of femur	Streptococcus viridans	Staph. albus	8th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
6	10	Upper end of femur	None	Staph. albus	8th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
7	12	Upper end of femur	None	Staph. albus	6th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
8	5	Lower end of femur	None	Staph. albus	4th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
9	15	Lower end of femur	None	Staph. albus	4th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
10	13	Lower end of femur	Streptococcus viridans	Staph. albus	5th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
11	8	Lower end of femur	Streptococcus viridans	Staph. albus	5th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
12	15	Lower end of femur	None	Staph. albus	5th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
13	12	Lower end of femur	None	Staph. albus	5th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
14	0	Upper end of femur	None	Staph. albus	5th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.

Case No.	Age (Yr.)	Bone Affected	Organism Found	Blood Culture	Duration of Symptoms before Admission (Days)	Operative Findings—Macroscopic Appearances					Microscopic Appearances					Subsequent Treatment	Result
						Site	Pus	Bone Destruction	Involvement of Epiphysis	Involvement of Joint	Site	Pus	Bone Destruction	Involvement of Epiphysis	Involvement of Joint		
15	8	Lower end of femur	None	Staph. albus	5th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
16	15	Lower end of femur	None	Staph. albus	5th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
17	12	Upper end of femur	None	Staph. albus	6th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
18	5	Lower end of femur	None	Staph. albus	4th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
19	15	Lower end of femur	None	Staph. albus	4th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
20	0	Upper end of femur	None	Staph. albus	4th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
21	8	Lower end of femur	None	Staph. albus	4th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
22	0	Upper end of femur	None	Staph. albus	4th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
23	15	Lower end of femur	None	Staph. albus	4th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.
24	0	Upper end of femur	None	Staph. albus	4th	Shaft	+	+	—	—	Shaft	+	+	—	—	Drainage of pus. Rest in bed.	Sinus healed in 3 weeks.

'Local' Response to Penicillin Treatment.—It has been shown that penicillin controls general infection, and it is now necessary to consider what form of local intervention, if any, is desirable.

The operative procedures which can be utilized include bone guttering, bone drilling, and incision or aspiration of subperiosteal abscesses.

FIG. 200.—*Case* 2. Intramedullary needle in position. Minor bone changes present. Septic arthritis proved by joint puncture.

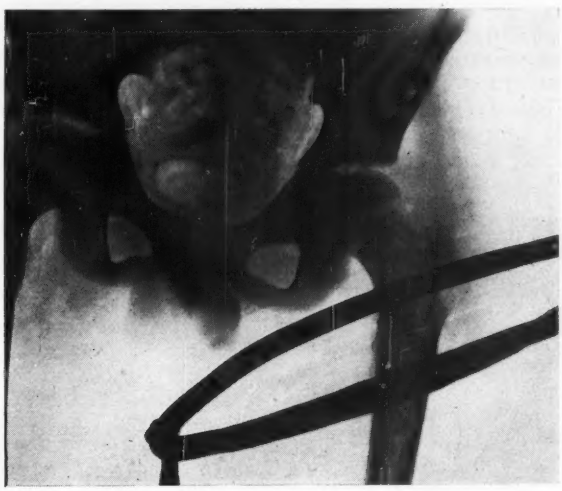


FIG. 201.—Same case, showing immobilization in a Thomas splint and increasing decalcification two weeks after penicillin treatment.

FIG. 202.—Same case. Stage of maximum decalcification six weeks after penicillin treatment. Apparent disorganization of bony architecture.

FIG. 203.—Same case. Stage of decalcification fifteen weeks after penicillin treatment. Reappearance of trabeculation and preservation of joint space.

1. Bone guttering is favoured by those who have as their guiding principle effective drainage, which, in their view, is procurable only by extensive removal of the cortex overlying the infected metaphysis. Certainly drainage is free, but inevitably healthy bone is exposed and there is danger to life from the displacement of septic thrombi.

2. Incision of subperiosteal abscess and bone drilling are attempts to combine effective drainage of the bone with a minimum of surgical interference.

3. Aspiration of subperiosteal abscess and immobilization in combination with the administration of sulpha drugs has been investigated in various centres, and the findings suggest that although there is a low mortality-rate, no dramatic improvement resulted in the local lesion in bone, where pus continued to form and sterilization was too slow to prevent the formation of sequestra.

In the great majority of our patients a conservative régime was followed in order that the effects of penicillin treatment could be observed uncomplicated by other factors.

Table III shows that in our series 32 patients with acute infections of long bones were treated with penicillin. Of these only 5 had operative treatment, the remaining 27 being treated conservatively. Of the 5 patients operated on 4 were amongst the first to be treated before the effectiveness of penicillin was fully appreciated, and were not selected according to the severity of the lesion. The remaining patient was a neglected case of 13 days' duration; a small incision was necessary to anticipate the development of a spontaneous sinus,

the skin being unhealthy and pus having already ruptured through the periosteum.

Aspiration of a subperiosteal abscess alone was carried out in 2 of the 27 patients treated conservatively, and in 15 a sternal puncture needle was inserted into the affected metaphysis for relief of intramedullary tension. Since there was no obvious abscess in the remaining 10 patients, 8 were treated by simple immobilization of the infected limb, and 2 were treated without immobilization. After aspiration, the subperiosteal abscess did not in any case progress to sinus formation. In *Case* 21 (*Table III*), 6 c.c. of thick pus were aspirated from the subperiosteal space on the fourth day of treatment, but further attempts to aspirate on the sixth day were unsuccessful, indicating that the metaphysial infection had been brought under control. In *Case* 19 (*Table III*), a large fluctuant subperiosteal abscess extended two-thirds up the shaft of the tibia, and it was possible to aspirate 8 c.c. of thick pus. Sequestrectomy has been unnecessary and exacerbations have not occurred in any of the patients treated by aspiration and immobilization.

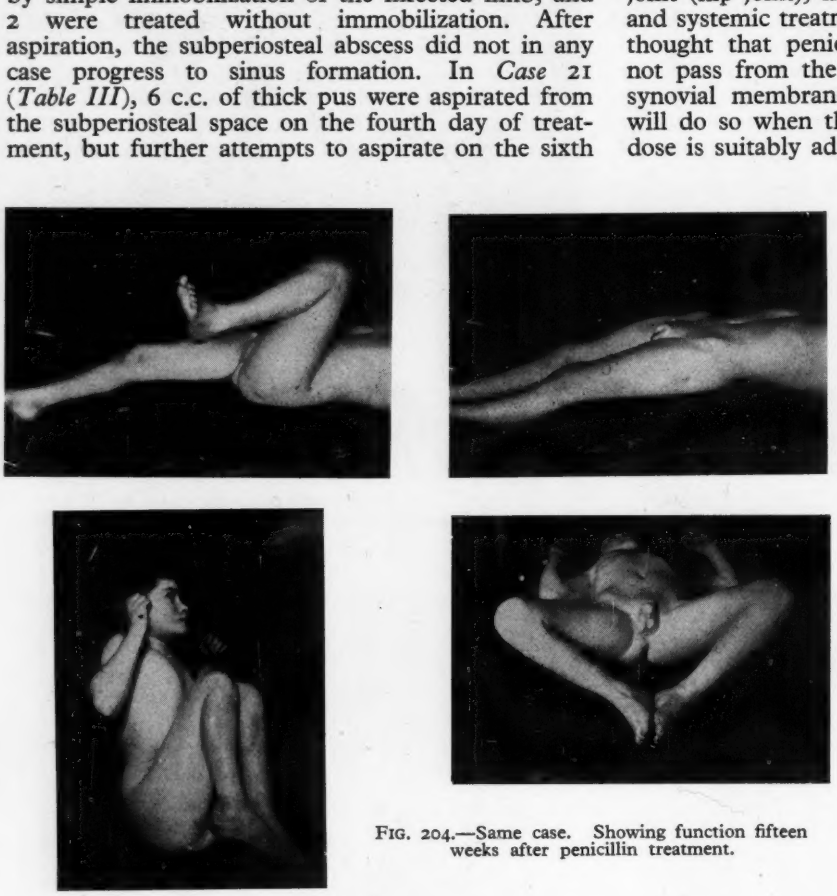


FIG. 204.—Same case. Showing function fifteen weeks after penicillin treatment.

The results of more extensive operative treatment in 5 patients have not been so encouraging. An excellent result was obtained in *Case* 30 (*Table III*), but in the other 2 cases (*Cases* 29 and 31, *Table III*), where it has been possible to assess the effectiveness of treatment, both developed sequestra which required removal, and still have discharging sinuses after 11 and 7 months respectively. The sequestra were superficial in type, and in each case corresponded to the point at which the periosteum had been raised at operation. The wounds became secondarily infected with Gram-negative organisms which caused a persistence of suppuration after the *Staph. aureus* had been eliminated. These patients required more attention than those treated without radical operation, and in addition their periods of hospitalization and incapacity were longer.

In 10 of the 40 patients septic arthritis occurred. This complication is probably most effectively treated by aspiration of pus and local injection of penicillin into the joint cavity every second day. Repeated aspiration of a relatively inaccessible joint (hip-joint), however, is not always practicable and systemic treatment has to be relied upon. It is thought that penicillin in detectable amounts will not pass from the blood-stream through a healthy synovial membrane, but there is evidence that it will do so when the joint is infected, provided the dose is suitably adjusted. All our patients received systemic penicillin treatment. In 5 local treatment was not possible on account of infection of a hip-joint; in 4 patients, as the limb was incorporated from the first day in plaster-of-Paris, a septic arthritis was not diagnosed; thus 1 patient only received additional local treatment. As a result of this treatment, 3 patients have complete destruction of the joint with bony ankylosis, 4 have a varying degree of limitation of movement, and 3 have complete return of function with no radiological evidence of previous infection (*Fig.* 203).

Except in patients with septic arthritis, the period of immobilization was reduced to a minimum in order that early active movements could be encouraged. Weight-bearing, however, was postponed until there was radiological evidence of recalcification.

Functional Results.—The causes of prolonged incapacity and poor functional results are massive sequestra formation, discharging sinuses, septic arthritis, and pathological fractures. It is possible to assess the effects of treatment in 22 of the 32 patients who had infection of long bones. In 2 poor function has resulted because of destruction of a joint, 1 has a pathological fracture, and 2 have discharging sinuses. In the remaining 17 patients good function has resulted.

Radiological Appearances.—An assessment of the sequence of the radiological changes which accompany the process of healing has been possible in 22 patients with infection of long bones. As already pointed out, penicillin treatment sterilizes bone on an average within 14 days (*see* p. 168). Before sterilization, damage to bone has occurred, but for some time the extent of damage does not become evident radiologically. Early radiological changes are evidence of the degree of initial bone damage; later changes are part of a process of healing, and cannot be attributed to continuing infection.

The outstanding radiological features in early infection are the extensive decalcification, the limited

amount of subperiosteal bone formation, and the absorption of small sequestra. Decalcification in most cases has been widespread, on occasion involving the whole of the infected bone. Patchy and ill-defined areas of rarefaction occur first in the metaphysial area and later spread to the adjacent shaft. For 70–140 days the decalcification is progressive, and owing to the small amount of periosteal new bone formation, the process can be readily observed. These changes presumably occur in cases not treated by penicillin, but they are masked by a denser involucrum. The trabeculations become ill defined and irregular to an extent which would suggest permanent structural disorganization of the bone (*Fig.* 202). In view of these changes, immobilization would appear advisable until there is radiological evidence of recalcification. *Fig.* 205

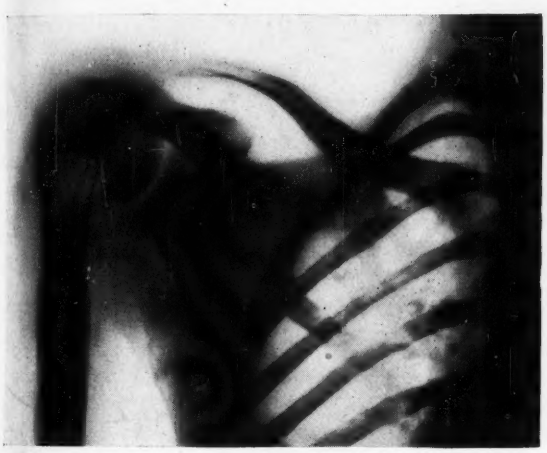


FIG. 205.—*Case* 26. Pathological fracture—limb not immobilized.

illustrates the danger of treatment without immobilization: a pathological fracture occurred through the epiphysis and adjacent shaft.

Small sequestra have developed in 5 of the patients treated conservatively, and the fate of these is being followed by repeated radiological examinations. In 2 cases complete absorption has been observed, and in the remaining 3 cases there is at present no indication that sequestrectomy will be necessary. The behaviour of these small sequestra appears to be similar to that of bone chips introduced to facilitate ossification—both are sterile and both require absorption before final healing can take place.

With one possible exception in a recent case still under treatment, excessive periosteal new bone formation has not occurred, nor has there been wide separation of the periosteum from the cortex, presumably because the bone destruction has not been so great as in cases treated without penicillin, and there is no necessity for massive involucrum formation to maintain support. Further, as pus formation is rapidly controlled by penicillin, the degree of periosteal elevation is limited.

Progress in Healing.—Recalcification is somewhat irregular but remarkably resembles the original pattern, more so than might have been anticipated from earlier X-ray examinations. *Fig.* 203 shows the reappearance of trabeculations after their apparent destruction (*Fig.* 202). The absence of massive sequestra has facilitated early healing; the absorption of smaller sequestra has resulted in localized areas of sclerosis. The interval which previously separated the subperiosteal new bone from the cortex has gradually narrowed, and fusion with the shaft has been interpreted as indicating that the lesion has become inactive. The limited amount of periosteal bone formation has maintained a moderately regular outline of the bone, and has prevented gross deformity (*Figs.* 206–210).

FIG. 206.—*Case* 21. Stage of 'healed' lesion (twenty-eight weeks).

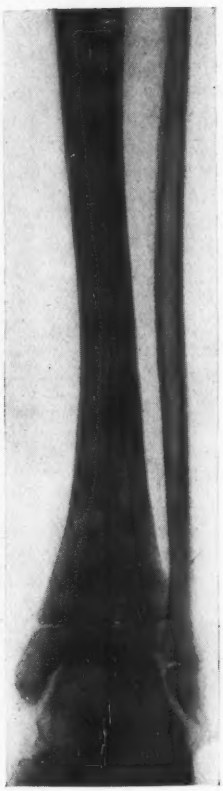


FIG. 207.—*Case* 18. Stage of 'healed' lesion (sixty weeks).

Prognosis.—Before the discovery of an effective chemotherapeutic drug, Kenny (1944) reported that in a series of 1547 cases there was a mortality of 23 per cent, and in toxic patients where the temperature reached 103° F. or where the patient was septicæmic, the mortality rose to 46 per cent. One-third of these patients developed metastases. With the introduction of the sulpha drugs, the mortality-rate has been reduced. Out of 38 consecutive cases treated with sulphathiazole in a ward of the Royal Hospital for Sick Children, there was a mortality of 10 per cent, and of 9 patients with a proved septicæmia 4 died.

In this series of 40 patients treated with penicillin there was only 1 death, despite the fact that 19 of these patients had a staphylococcal septicæmia, 9 had metastatic lesions, and 10 had a septic arthritis. This patient had a partially resistant *Staph. aureus* infection (four times more resistant than standard

Oxford *Staph. aureus*) and died from bronchopneumonia 42 days after the start of treatment. None of the septicæmic patients developed new metastatic lesions after the start of treatment.

It appears, therefore, that recovery can be anticipated in every patient with acute hæmatogenous osteomyelitis treated with penicillin, provided that the infecting organism is penicillin-sensitive and that the patient is not *in extremis* when first seen. It is possible that for these reasons the general mortality-rate will remain in the neighbourhood of 5 per cent.

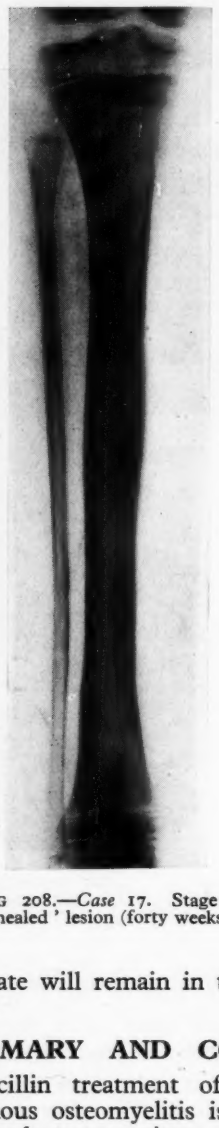


FIG 208.—*Case* 17. Stage of 'healed' lesion (forty weeks).

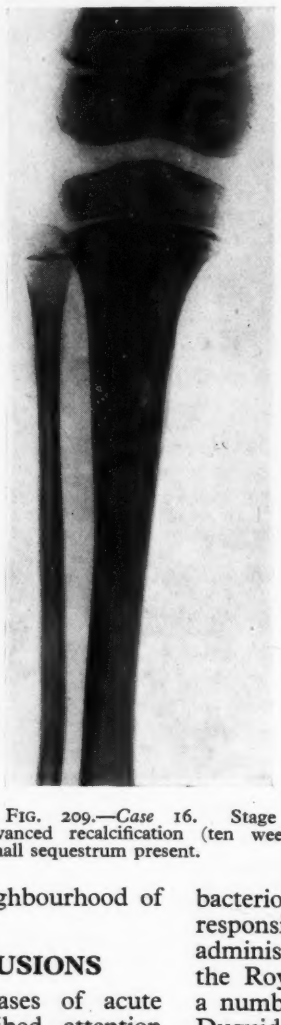


FIG. 209.—*Case* 16. Stage of advanced recalcification (ten weeks). Small sequestrum present.

FIG. 210.—*Case* 14. Stage of 'healed' lesion (twenty-four weeks).

SUMMARY AND CONCLUSIONS

1. Penicillin treatment of 40 cases of acute hæmatogenous osteomyelitis is described, attention being focused on 32 patients with infection of long bones.

2. The mortality was 2·5 per cent, despite a 50 per cent incidence of *Staph. aureus* septicæmia.

3. The best results were obtained when conservative methods were employed. Secondary infection with penicillin-resistant organisms was obviated, no spontaneous sinus developed, and as yet sequestrectomy has not been necessary.

4. Radiologically it would appear that devitalization has been cellular rather than massive, as shown by the absence of large sequestra and of massive involucrum formation, the preservation of bony architecture, and the absence of gross deformity.

Acknowledgments.—Some of these cases have been treated by penicillin supplied for research purposes through the Penicillin Clinical Trials Committee of the Medical Research Council.

I wish to thank Professor J. R. Learmonth, whose help and advice have made this work possible; Professor T. J. Mackie, in whose department the bacteriology was carried out; Mr. Ian Aird, who is responsible for the method of intramedullary administration of penicillin and in whose wards in the Royal Hospital for Sick Children, Edinburgh, a number of the patients were treated; Dr. J. P. Duguid for much help with the clinical and bacteriological work; and Dr. R. McWhirter for his interest and help in the interpretation of the X-ray films. I am also indebted to the surgeons-in-ordinary of the Royal Infirmary, Edinburgh, for permission to treat patients in their wards.

The illustrations have been prepared by the technical staff of the Wilkie Surgical Research Laboratory, University of Edinburgh.

REFERENCE

KENNY, W. E. (1944), *Surgery*, **16**, 477.

THE STATUS OF HORMONAL BIOASSAY IN MALIGNANT DISEASE OF THE TESTICLE

A REVIEW OF THE LITERATURE

By R. S. FRANCIS, Surg.-Lieut., R.N.V.R.

Controversy has raged for decades over the subject of growths of the testicle. The giant protagonists of the early days were Ewing and Chevassu. Followers of the former believed most tumours to be derived from totipotent cells, which conveniently accounted for the bewildering heterogeneity and varying malignancy of such growths, whilst supporters of the latter contended that there was in addition a distinct group of neoplasms derived from the spermatic tubule cells, to which Chevassu gave the name seminoma. Such tumours have been recognized histologically by common consent, and their integrity has been respected by most authors. As to the status of the heterogenous group, the nomenclature has become confounded beyond all reason. 'Teratoma' has come to connote any malignant or benign neoplasm of the testicle with the possible exception of the seminoma. Other names are applied, depending on the type of tissue which predominates. Thus, chorionepitheliomata, embryonal adenocarcinomata, and carcinomata, "teratoid with cancerous elements", mixed adult types with cancerous areas, malignant types with adult tissue, and all the possible permutations of tridermic growths of varying malignancy which, on account of their mixed structure, do not justify separate classification.

A further fillip was given to this controversy when Zondek published in 1930 his discovery that malignant tumours of the testis caused the urine of their owners to give a positive Aschheim-Zondek pregnancy test. The subsequent fourteen years, therefore, saw a series of attempts to correlate hormone production with prognosis, and a tendency to re-classify these growths on a hormonohistologic basis. Notable amongst these investigators were Ferguson (1933), Herger and Thibandear (1934), Cutler and Owen (1935, 1936, and 1937), Hinman and Powell (1938), Hamburger (1936), Twombley et al. (1942), Rosenblatt et all. (1942), Ferris (1943), and other writers who reported one or two cases (Beilly et al., 1940; Fortner and Owen, 1935), and still others who did not publish their figures. All these writers used material ranging from untreated urine to acid-alcohol precipitated extracts, or urine treated by the benzoic acid floc technique. Again, the interpretation of the quantitative tests tended to differ, and there has been variation in the test animal used (rat, rabbit, mouse). Conclusions have ranged from encouraging to disappointing, confusing to convincing—in fact, they have been anything but uniform.

Thus to the clinician confronted with a tumour of the testicle any attempt to consult the literature on the significance of the Aschheim-Zondek reaction is bound to prove somewhat disappointing at our present stage. It was with this in mind that the work embodied in the present paper was undertaken.

Most of the available literature for the last fourteen years, following Zondek's observation, has been reviewed, and special attention has been paid to those authors who have published investigations of large numbers of cases. The field covers over 300 tumours of the testis, mostly malignant, and varying in their histology from the adult type of 'teratoma' through an increasing range of embryonic-cell type and malignancy to the chorionepitheliomatous type or growth. For details of cell type, hormone output and reference, *see Table I*, which is an attempt to incorporate in one unit all the varying terminologies used by different investigators, with their hormonal figures. *Table II* is an abstract of the figures, and here certain sub-groups of tumours are unified under a few main headings. *Table III* represents a simplified classification of all the cases collected, with the exception of those in *Table IV*, which consists of results of Hamburger's series.

DISCUSSION ON THE TEST

Zondek in 1930 examined the urine of patients suffering from malignant disease of the testis. He found that, as with pregnant women's urine, the following results were obtained in the test animal's ovary:—

1. Ripening of the Graafian follicle.
2. Hæmorrhage into the cyst.
3. Gross enlargement of the uterine horns.

Ferguson in 1933 stressed the importance of reaction (1) in male urine, and interpreted the occurrence of reactions (1) and (2) in 1 ml. of urine as indicating the presence of 1000 mouse units per litre. If luteinization and the formation of corpora atretica occurred (reaction 3), then Ferguson simply inferred that there was five times as much hormone (i.e., 5000 m.u./.l) present in the urine than was indicated by reaction (1) and (2) alone. (By using concentrated urine, as few as 100 m.u./l. could be demonstrated.)

But in 1936 Hamburger pointed out the following data: The anterior pituitary hormone causes follicle-stimulation, whereas the main action of the chorionic hormone is in the formation of corpora lutea. Furthermore, Helga Gerber (Paris, 1933) had shown that seminomata produced either no hormone at all or a small quantity of follicle-stimulating hormone (F.S.H.), whereas other tumours produced both F.S.H. and the chorionic or luteinizing hormone. Zondek confirmed this in 1935, but doubted its diagnostic value. Hamburger's other point was that in cases of seminoma causing the excretion of F.S.H., the tumour itself was not shown to contain any F.S.H., the presumption being that the latter was produced in the pituitary. The effect of castration was also to cause an increase in F.S.H. Thus, Hamburger assessed the two

hormones separately and found in cases of seminoma only F.S.H., and low titres at that, whereas in other tumours he found chorionic hormone with titres mostly of a higher level. These are to be found in *Table IV* and are discussed later.

Ferris published in 1943 the results of a series of cases and claimed that neither the Aschheim-Zondek nor the Friedman test were as sensitive as the Frank test in which rats are used. He states that the Aschheim-Zondek test does not give positive readings below the equivalent of 66 rat units, and that the borderline of malignancy is 20 rat units/litre. He recommends routine testing for 25, 40, and 66 r.u./l., claiming that the Frank test is sensitive down to titres of 5 r.u./l. However, others report quantitative readings by the Aschheim-Zondek technique as low as 50 and 100 m.u./l. before the test becomes negative, and the borderline of malignancy does not appear to be substantially lower than these figures.

A number of investigators have concerned themselves with normal control observations, and also controls in cases of inflammatory or granulomatous lesions of the testis. Thus, in 1935, Cutler and Owen quote Zondek (1932) as having examined 40 normal cases and Ferguson (1933) 200 normal cases.

In their own paper, 13 normals showed titres all below 50 m.u./l. Again in 1936, Cutler and Owen assayed 500 males with normal testes or benign lesions. All were negative. Higgins and Buchert (1939) quote Branch (personal communication cited by Ferguson) and report assays on 500 men, in which only 2 cases excreted hormone, these being 2 cases of teratoma. Read (1939), however, suggests that the castrating effect of disease in testes may exert some influence on the gonadotropin output. Ferguson (1931) reports 24 benign lesions —all negative, 15 carcinomatous patients with normal testis—all negative, and 12 cases of teratoma testis, giving 9 positive assays and 3 negative (the latter three had been cured of their disease). McDougall and Graham in 1943, however, quote 3 cases of parotid tumour (100 to 150 m.u./l., 1 case of testicular gumma (for years 1000–2000 m.u./l. post-operatively) 2 cases of hæmangioma (200–500) and 1 case of undescended testis (pre-operatively 200, one year later 1000 m.u./l. Acromegaly has also been reported as causing an increase in hormone output (Herger and Thibandear, 1943). They conclude that conditions other than teratoma of the testis may cause an increase in hormone output, but this is usually of a low level.

Views on the Value of the Test.—

1. All are agreed that the test, in conjunction with other factors, is a valuable aid to diagnosis. With the exception of a few dissenters, notably McDougall and Graham (1943), Barringer, quoted by these authors, and Rosenblatt (1942), there is general agreement with Ferguson's view—namely, that hormone output tends to vary indirectly with the degree of cellular maturity of the tumour. Thus, maximum output (mostly from 10,000 to 200,000 m.u./l.) is achieved by chorionepitheliomatous types of growth, and the minimum (mostly 0–500 m.u./l.) by the adult type teratomata (*see Table II*). Perhaps, as Read (1939) comments, there is generally " not such clear distinction " as Ferguson found, but, on the whole, one is probably on safe ground in making this general deduction. Ferris (1943) simply states that all malignant tumours cause the excretion of excessive amounts of hormone.

2. To accept the above as a rule of thumb, however, is not justifiable, as the figures show so much overlap, and there are too many exceptions to the rule. In the light of our present knowledge, and the limitations of the test, one cannot foretell the histological type of the tumour from bioassay of the urine alone (McDougall and Graham, 1943; Twombley et al. 1942; Rosenblatt, 1942).

3. As to prognosis, the constant association of high titres with high degrees of malignancy and fatal outcome is most impressive. Twombley, Temple, and Dean (1942), who spent eight years collecting 203 patients and analysing the prognosis of 47, state that there was correlation between hormone levels and clinical course.

Consistently high levels tended to fatal outcome. In July, 1939, of 203 patients collected from 1931–1939 :—

Those with	1000 m.u./l. or less had	33 per cent mortality
" "	1000–2000 m.u./l. had	57 per cent "
" "	2500 m.u./l. or above had	82 per cent "
" "	10,000 on more than 1 test had	100 per cent "

Cutler and Owen (1935) concluded that the test was of value in diagnosis and prognosis in 66 cases. Ferris (1943) thought 20 rat units was the dividing line between normal and excessive amounts. Ferguson (1933), in his study of 117 cases, concluded that teratomata titres varied from 50–50,000 depending on embryonal character of the tumour, extent, and " status as regards treatment ". Hamburger attached " great prognostic significance " to the test. It cannot, however, be said that low titres have invariably better prognoses (*see below*, under next paragraph), but one has the definite impression from the literature that the lower readings given, for example, by seminomata appear to imply a somewhat brighter future (Powell, 1938; Hinman and Powell, 1938; Hamburger, 1936; Twombley et al., 1942). But McDougall and Graham (1943) conclude that the test is no indication of malignancy, prognosis, or effect of treatment.

4. The significance of a negative reaction in a case of suspected tumour of the testis is a thorn in the diagnostician's side. There are abundant examples of negative assays being consistent with malignancy. This is found in many cases of seminoma and in some cases of other malignant growths. In McDougall's series of 36 pre-operative estimations, 25 per cent of the negatives had proven malignancy. Owen and Cutler (1936) consider that patients with teratoma excrete more than 100 m.u./l. in general. False negatives and false positives occurred in 10 per cent of assays. Stevens (1940) remarks " if the urine of a man with a testicular tumour contains 50 r.u./l., or less, it is considered either a benign tumour of a seminoma; 30 per cent of seminomas gave a negative test in Hamburger's series.

5. What is the value of the test as an indication of the effectiveness of treatment? Most authors are agreed that the value is not inconsiderable. Ferguson concluded that when the output dropped to less than 400 m.u./l. within two weeks of the completion of treatment, the prognosis was good.

Table I.

EMBRYONAL ADENOCARCINOMA

Embryonal Adenocarcinoma

No. of Cases	Mouse Units/Litre	Author
7	1000–40,000	Ferguson, 1933
1	64,000*	Twombley et al., 1942
1	40,000*	Twombley et al., 1942
1	5000*	Twombley et al., 1942
1	400*	Twombley et al., 1942
4	2000*	Twombley et al., 1942
3	< 100*	Twombley et al., 1942
5	100–500	Twombley et al., 1942
1	Neg.	Twombley et al., 1942
5	1000–2000	Twombley et al., 1942
3	10,000	Twombley et al., 1942
6	2000–1,000,000	Powell, 1938
6	1000–16,000	Owen and Cutler, 1937
44	0–1,000,000	

Embryonal Adenocarcinoma with Lymphoid Stroma

No. of Cases	Mouse Units/Litre	Author
3	100	McDougal and Graham, 1943
1	Neg.	McDougall and Graham, 1943
1	400	McDougall and Graham, 1943
14	200–5000	McDougall and Graham, 1943
19	0–5000	

63 cases at 0–1.000,000
Mostly 100–50,000
Above 50,000, less than 6 per cent
Above 70,000, 1 case only (1,000,000)

TERATOMATA—ALL TYPES

Chorionepithelioma or with Choriomatous Elements

No. of Cases	Mouse Units/Litre	Author
1	50,000	Ferguson, 1933†
1	200,000*	Twombley et al., 1942
1	100–150*	Twombley et al., 1942
2	1000–2000	Twombley et al., 1942
1	10,000	Twombley et al., 1942
1	10,000	Fortner and Owen, 1935
1	125,000	Fortner and Owen, 1935
4	20,000–3,000,000	Powell, 1938
1	30,000	McDonald, 1938
2	10,000–125,000	Owen and Cutler, 1937
15	100–3,000,000	

15 cases mostly from :—
10,000–200,000
Above or at 200,000, 2 cases (12 per cent)
Above 100,000, 5 cases (30 per cent)
Above 50,000, 7 cases (50 per cent)
Highest, 3,000,000
Below 10,000, 3 cases (less than 20 per cent)

'Malignant Teratoma'

No. of Cases	Mouse Units/Litre	Author
1	46,000	Beilly et al., 1940

Differentiat Cancerous E

No. of Cases	Mouse Units/Lit
1	200
2	1000–2000
8	500–100,000
1	1000
12	Cases, mostly 500– 2000 or less

15 Miscellaneous malignant teratomas, m
N.B.—This is probably a very mixed

TERATOMATA—ALL

'Teratoma'

No. of Cases	Mouse Units/Litre	Author
69	< 100–125,000 (Average, 950)	Owen and Cutler, 1936

These are not included in the total, since they may overlap with figures in another paper by the same author (Owen and Cutler, 1937)

Mixed Teraton Feat

No. of Cases	Mouse Units/Lit
5	50–500

Be
B

EMBRYONAL CARCINOMA

Embryonal Carcinoma

No. of Cases	Mouse Units/Litre	Author
1	20,000*	Twombley et al., 1942
1	10,000*	Twombley et al., 1942
3	< 200*	Twombley et al., 1942
2	1000	Herger and Thibandear, 1943
2	2000	Herger and Thibandear, 1943
1	200	Herger and Thibandear, 1943
10	< 200–20,000	

Embryonal Carcinoma with Lymphoid Stroma

No. of Cases	Mouse Units/Litre	Author
15	2000–10,000	Ferguson, 1933
1	400	McDougall and Graham, 1943
4	Neg.	McDougall and Graham, 1943
2	< 100	Herger and Thibandear, 1943
3	1000	Herger and Thibandear, 1943
1	75	Herger and Thibandear, 1943
1	2000	Hinman and Powell, 1935
27	0–10,000	

Embryonal Carcinoma, Primitive or Undifferentiated

No. of Cases	Mouse Units/Litre	Author
8	1000–10,000	Powell, 1938

Embryonal Carcinoma Differentiated

No. of Cases	Mouse Units/Litre	Author
36	100–1000	Powell, 1938

Carcinoma (Solid 'Semino

No. of Cases	Mouse Units/Li
1	Neg.
1	5000
1	100–150
5	200–500
1	10,000
6	2000–2500
1	10,000
3	1000–1500
19	0–10,000 16 at 0–2500

81 embryonal carcinomata varying from 0–20,000
80 cases were 0–10,000 (99 per cent)
At least 58 cases were 2000 or less (70 per cent)

* Figures so marked are taken from one of two tables published by Twombley et al. (1942). An attempt has been made to avoid quoting figures from one table which may overlap the ot

L ADENOCARCINOMA

	Embryonal Adenocarcinoma with Lymphoid Stroma		
	No. of Cases	Mouse Units/Litre	Author
933	3	100	McDougal and Graham, 1943
et	1	Neg.	McDougall and Graham, 1943
et	1	400	McDougall and Graham, 1943
et	14	200–5000	McDougall and Graham, 1943
et	19	0–5000	
et			
et			
et			
et			
et			
et			
7			

t 0–1.000,000
100–50,000
ess than 6 per cent
case only (1,000,000)

EMBRYONAL C

	Embryonal Carcinoma with Lymphoid Stroma		
	No. of Cases	Mouse Units/Litre	Author
t	15	2000–10,000	Ferguson, 1933
t	1	400	McDougall and Graham, 1943
t	4	Neg.	McDougall and Graham, 1943
	2	< 100	Herger and Thibandear, 1943
	3	1000	Herger and Thibandear, 1943
	1	75	Herger and Thibandear, 1943
	1	2000	Hinman and Powell, 1935
	27	0–10,000	

81 embryonal carcinomata
80 cases were 0–10,000
At least 58 cases were 20

n from one of two tables published by Twombl

Table I.

TERATOMATA—ALL TYPES

Chorionepithelioma or with Choriomatous Elements			'Malignant Teratoma'			Differentiated with Cancerous Elements			Mixed Embryonal Teratoma		
No. of Cases	Mouse Units/Litre	Author	No. of Cases	Mouse Units/Litre	Author	No. of Cases	Mouse Units/Litre	Author	No. of Cases	Mouse Units/Litre	Author
1	50,000	Ferguson, 1933†	1	46,000	Beilly et al., 1940	1	200	Twombley et al., 1942	1	10,000	Hinman and Powell, 1935
1	200,000*	Twombley et al., 1942				2	1000–2000	Twombley et al., 1942	1	2000	Hinman and Powell, 1935
1	100–150*	Twombley et al., 1942				8	500–100,000	Powell, 1938			
2	1000–2000	Twombley et al., 1942				1	1000	Hinman and Powell, 1935			
1	10,000	Twombley et al., 1942				12	Cases, mostly 500–100,000 2000 or less (50 per cent)				
1	10,000	Fortner and Owen, 1935									
1	125,000	Fortner and Owen, 1935									
4	20,000–3,000,000	Powell, 1938									
1	30,000	McDonald, 1938									
2	10,000–125,000	Owen and Cutler, 1937									
15	100–3,000,000										

15 cases mostly from :— 10,000–200,000
Above or at 200,000, 2 cases (12 per cent)
Above 100,000, 5 cases (30 per cent)
Above 50,000, 7 cases (50 per cent)
Highest, 3,000,000
Below 10,000, 3 cases (less than 20 per cent)

15 Miscellaneous malignant teratomas, mostly from 500 m.u./l. to 50,000 m.u./l.
N.B.—This is probably a very mixed histological group

TERATOMATA—ALL TYPES, *continued*

'Teratoma'			Mixed Teratoma with Adult Features			'Adult Teratoma'		
No. of Cases	Mouse Units/Litre	Author	No. of Cases	Mouse Units/Litre	Author	No. of Cases	Mouse Units/Litre	Author
69	< 100–125,000 (Average, 950)	Owen and Cutler, 1936	5	50–500	Ferguson, 1933	1	Neg.	McDougall and Graham, 1943
						5	500–1000	McDougall and Graham, 1943
						3	Neg.	Hinman and Powell, 1938
						2	0–500	Twombley et al., 1942
						2	< 100	Powell, 1938
						13	0–1000	

These are not included in the total, since they may overlap with figures in another paper by the same author (Owen and Cutler, 1937)

Less than 100, 7 cases (55 per cent)

18 adult or mixed teratomas at 0–1000
Below 500 m.u./l., 11 cases (60 per cent)
Below 100 m.u./l., 8 cases (45 per cent)
'Adult' types below 100, 55 per cent

...ONAL CARCINOMA

	Embryonal Carcinoma, Primitive or Undifferentiated			Embryonal Carcinoma Differentiated		
thor	No. of Cases	Mouse Units/Litre	Author	No. of Cases	Mouse Units/Litre	Author
on, 1933	8	1000–10,000	Powell, 1938	36	100–1000	Powell, 1938

...arcinomata varying from 0–20,000
0–10,000 (99 per cent)
...s were 2000 or less (70 per cent)

SEMINOMA

Carcinoma (Solid or Lymphoid) 'Seminoma'			'Seminoma'		
No. of Cases	Mouse Units/Litre	Author	No. of Cases	Mouse Units/Litre	Author
1	Neg.	Twombley et al., 1942	10	(Average, 1000) 400–2000	Ferguson, 1933
1	5000	Twombley et al., 1942	17	200–500	McDougall and Graham, 1943
1	100–150	Twombley et al., 1942	1	5000	McDougall and Graham, 1943
5	200–500	Twombley et al., 1942	9	< 100	Powell, 1938
1	10,000	Twombley et al., 1942	2	100–200	Owen and Cutler, 1937
6	2000–2500	Twombley et al., 1942	39	at 0–5000	
1	10,000	Twombley et al., 1942			
3	1000–1500	Twombley et al., 1942			
19	0–10,000				

16 at 0–2500 (80 per cent)

Average figure well below 1000
75 per cent, 500 and below
25 per cent at 0–100
One case only above 2000

...y Twombley et al. (1942). An attempt has been made to avoid quoting figures from one table which may overlap the other.—R. S. F.

† Quoting Heidrich.

Irradiation caused a decrease in output, and local recurrence was heralded by an increase often before it became clinically recognizable. That surgery or irradiation caused a decrease in output accompanied by an improved prognosis was confirmed by Cutler and Owen (1935; 1936), who also found that a rising or stationary titre after treatment was a bad omen, such a rise being attributable to local recurrence or metastasis. Ferris (1943) quotes Cabot and Berkson (1939), *New Eng. J. Med.*, as giving these figures :—

Seminomas	without	metastasis	alive	10	yr.	or	more	post-operative	50·5 per cent
,,	with	,,	,,	10	,,	,,	,,	,,	37·5 ,, ,,
Other tumours	without	,,	,,	10	,,	,,	,,	,,	35 ,, ,,
,,	with	,,	,,	10	,,	,,	,,	,,	10 ,, ,,

(These figures are considerably higher than those given by Higgins and Butchert (1939), who found in 83 patients with malignant tumours of the testis that those without clinical evidence of metatases when first seen had only a 30 per cent five-year survival rate; 9 per cent survived 10 years. Most other writers (Tanner, 1922; Hinman, 1933; Young, 1926; Dean, 1934), quoted by Higgins and Buchert, give round about a 20 per cent or less five-year survival rate for all tumours, although Payne (1938), in a five-year follow-up gives 15 out of 38 as being alive after that time.)

Both Ferris and Hamburger found seminomas more susceptible to irradiation. The latter concluded that these tumours were less malignant and had better prognosis, whereas the remainder were mostly resistant to irradiation, having a bad prognosis. Powell (1938), and Hinman and Powell (1938), conclude that persistence at or above 500 m.u./l. indicates residual metastatic tissue, but not necessarily active tissue. The disappearance of the hormone was not nearly so significant as its persistence at abnormally high levels. Such persistence (400 m.u./l. indicated unquestionably that residual neoplastic tissue was present, while the disappearance of the hormone did not always mean the absence of malignant cells. The figure quoted coincides with that mentioned by Ferguson, below, which, within two weeks of treatment, a favourable prognosis might be expected.

McDougall and Graham, however, concluded that post-treatment levels of hormone were no help as a guide to treatment. They might increase appreciably in 75 per cent of cases. Only 6 out of 23 living patients returned to less than 200 m.u./l., whereas 4 out of 23 who died also returned to this level.

The Limitations of the Test.—In its present stage the test is subject to difficulties of interpretation, and the figures in *Table I*, showing as they do a considerable overlap, must not be accepted rigidly for these reasons :—

1. The technique of extracting the hormone varies: untreated urine, alcoholic extraction, and the benzoic acid floc method are three examples. Again, accuracy depends on the number of mice used per level of assay. Rats and rabbits are used by some.

2. Interpretation of the ovarian changes is empirical and variable. This has been discussed already.

3. Obviously the titre must vary directly with the mass of the growth, or that portion of a mixed growth producing the hormone. Further, a small primary with a small secondary might produce a lower titre than a single operable primary, in which the prognosis, estimated pre-operatively on a hormonal basis might appear to be worse than in the former case.

4. By no means all of the figures in *Table I* represent pre-operative titres.

5. Some authors assay 'morning urine', others, more accurately, use 24-hour specimens, thus ruling out renal sources of error.

An abstract of the above figures is given below in *Table II* alongside the figures given by Ferguson, with which they are interesting to compare. It is seen that there is general agreement with the latter's findings. In the present stage of the test, however, there are very few grounds for attempting to foretell the histological type of the tumour from an assay of the urinary hormones.

Table II.

Abstract of Table I			Ferguson's Figures		
No. of Cases	*Histological Type*	*M.U./L.*	*No. of Cases*	*Type*	*M.U./L.*
15	Chorionepitheliomatous	10,000–200,000 50 per cent above 50,000	1	Choriomatous	50,000 and over
15	Miscellaneous or mixed teratomas	500–50,000	7	Adenocarcinoma	1000–40,000
63	Adenocarcinomas	100–50,000 30 per less than 2000			
81	Carcinomatous types	0–10,000 70 per cent 2000 or less	15	Carcinoma	2000–10,000
39	Seminomas	Average less than 1000 75 per cent less than 500	10	Seminoma	400–2000, average 1000
18	Mixed, with adult types Purely adult	0–1000 60 per cent less than 500 55 per cent less than 100	5	Mixed, with adult types	50–500

It is seen from *Table II* that urinary hormone assay provides a basis for dividing the tumours into three main groups as has been done in *Table III*. Apart from the rare dermoid cyst, there is a relatively benign* group of adult or near-adult tumours

* The purely benign tumour of the testis is a rarity. The group is described as 'relatively benign' so as to contrast it with the embryonal teratoma, which is notoriously malignant.

(' mixed adult teratoma ') producing, in 60 per cent of cases, less than 500 m.u./l., of which the ' adult ' type were in 55 per cent of cases producing less than 100 m.u./l. Then there is the next group comprising what most observers are content to call ' seminomata ', giving somewhat similar titres (but higher if one includes ' carcinoma-seminomas ', of which 80 per cent are 0–2500 m.u./l.). Then, finally, there is the group (' embryonal teratoma ') comprising choriomatous, adenocarcinomatous, carcinomatous, and ' malignant teratomatous ' types, forming the upper level of excretion at a range of 1000–2000 units up to 50,000 and more, being in extreme cases up to 1,000,000 and 3,000,000.

Table III.

Tumour	Suggested Classification	M.U./L.
Cystic teratoma or dermoid	Dermoid cyst (benign)	
Adult or mixed teratomas	' Mixed adult teratoma ', benign or malignant	0–1000. 60 per cent are less than 500. Of adult types, 55 per cent are below 100
Seminoma	' Seminoma ', malignant	Average level well below 1000. 75 per cent are below 500. Only 25 per cent are below 100
Chorionepithelioma, adenocarcinoma, carcinoma, malignant teratoma, all types	' Embryonal teratoma ', malignant	1000–50,000. 1–3 millions in extreme cases

In *Table III* the tumours considered are unified under three main headings, constituting a simplified classification.

This brings us to Hamburger's figures (*Table IV*), which were not included in *Table I* since, for reasons stated earlier, interpretation did not afford a basis for general comparison.

*Table IV.**

No.	Histology	M.U./L.
7	Seminoma	None demonstrable
10	"	100–400. Mostly less than 200 F.S.H.
4	' Mixed epithelioma '	20,000 or over chorionic hormones
1	" "	100–300 " "
1	" "	50 " "
1	" "	100 " "
1	" "	100–150 mixed hormones
1	" "	3000 chorionic hormones
1	" "	200 " "
1	" "	None demonstrable
1	Teratoid, benign	50–100 F.S.H.

* [Excluding 1 case of seminoma giving 100–25,000 over various assays. Unlike all the other seminomas, this one resisted X rays. One case of mixed epithelioma (' embryonal teratoma ') gave 20,000–50,000 (*Case* 16), and photographs published by Hamburger showed chorionic tissue mixed with other histological types.]

Thus seminomas were either negative or mostly less than 200 m.u./l., and ' mixed epitheliomas ' were mostly (65 per cent) at or above 200 m.u./l. varying up to over 20,000 m.u./l. in a case with choriomatous tissue. These figures are on the whole lower than those in *Table I*, and the following reasons may help to account for this :—

a. Where there are no demonstrable hormones, Hamburger points out that this does not imply that the normal output is not exceeded. It is possible that the test is not sufficiently delicate.

b. In fact, the test is performed either on " untreated urine ", or after " alcohol precipitation after the Bidel-Zondek method ". Again, Twombley et al. (1942), point out that simple alcoholic extraction may not take up all the hormone.

c. It is presumed that while estimating chorionic hormone on the basis of the occurrence of hæmorrhage and luteinization of the follicle (follicle enlargement on its own merely indicating the presence of F.S.H.), the quantitative result is bound to be lower than if " gonadotropin " (i.e., both F.S.H. and chorionic hormone) is assessed singly on the basis of any of the three changes in the ovum, as in Ferguson's interpretation.

d. Hamburger's figures are compiled from assays after removal of the primary tumour in most cases.

DISCUSSION

Briefly, then, the position is this :—

There appear to be two hormones, A and B, in the urine of patients with tumours of the testis. Hamburger's work suggests that seminomas are responsible for small amounts of A, producing reactions (1) and (2), and teratomas for larger amounts of B plus A, producing reactions (1), (2), and (3). It is thus essential to assay both hormones separately if the test is to be of any real scientific value. Ferguson and his followers have not taken this into account, having simply assayed total hormones on an empirical basis, and constructed a loose sliding scale of mouse units to correspond with the pathological differences between the particular neoplasms. The presence of reaction (3) is here taken to indicate a five-fold multiple of the titre required to produce reactions (1) and (2). The qualitative difference involved here is thus ignored. There appears to be little scientific rationale to justify this latter interpretation, and

although Ferguson's work anteceded that of Hamburger by three years, it is difficult to understand why subsequent observers appear to have brushed aside Hamburger's facts, although these have been stressed by Twombley (1942), and mentioned by Ferris (1943).

It would seem, therefore, that a very good case exists for attempting to confirm the existence of the two urinary hormones, assaying them separately, and finally assaying the tumours themselves in every case. In this way it could be ascertained whether in fact seminomata cause only F.S.H. to appear in the urine but not in their own tissue, whereas embryonal teratomas cause both hormones to appear in the urine and probably play a part in the elaboration of chorionic hormone actually in their own tissues. Titres estimated by this method could then be compared with another scale of readings produced by assaying the hormones together after Ferguson's interpretation, and the results could be compared. (It is interesting to note that Beilly et al. (1940) found in a teratoma 142 m.u. of F.S.H. and 43 m.u. of chorionic hormone per gramme of tumour.) If Hamburger's premises were confirmed then an adjustment of technique and interpretation might bring a greater degree of uniformity into the results of urinary hormone assay, and the three groups of tumours might become better defined hormonally, though this would not alter the effect of variations in the size of tumours, or the fact that one embryonal teratoma might contain a preponderance of choriomatous tissue, giving a high titre, whereas another might be predominantly carcinomatous, giving a lower titre.

Comments on Technique.—Owen and Cutler (1937) suggest that the benzoic acid floc technique is preferable if the urine contains toxic substances. Also they claim (1935) greater accuracy where small amounts of hormone are concerned by a modification of the benzoic acid technique of Doisy and Katzman. Twombley et al. (1942) notes that alcoholic extraction gives a varying yield of hormone, and stresses the need for more mice per assay for each given level of hormone. Ferris (1943) considers the Frank technique most suitable, and suggests routine testing for 25, 40, and 66 m.u./l.

Treatment.—Tanner's collection of 465 simple orchidectomies without X rays had only 5½ per cent four-year survivals (quoted by Roche, 1933).

Irradiation and orchidectomy are the surgeon's weapons. Orchidectomy alone provided 24 per cent of the five-year survivals in Higgins and Buchert's series (1939), whereas orchidectomy plus X rays provided 35·5 per cent. The question is whether irradiation should precede as well as follow operation. McDougall and Graham (1943) suggest that the effect of irradiation is useful as an adjunct to diagnosis. A theoretical advantage is that if such treatment causes a drop in hormone output, the diagnosis is confirmed and the risk avoided of operating on an inflammatory lesion. This would appear to have little advantage besides delaying surgical removal of a tumour probably of great malignancy. A disadvantage is that pre-operative irradiation distorts the histological picture.

It would appear reasonable to perform simple orchidectomy as the operation of choice (Roche, 1933) immediately the diagnosis is made (or to explore if in doubt) and follow up routinely with irradiation, especially of the aortic glands whether or not metastases were suspected. This routine would cause fibrosis of the lymph-drainage system, thus avoiding the spread of a possible local recurrence subsequent to treatment.

The five-year survival rate may be misleading as an index of final cure. A case is reported (Zerman, 1943) of recurrence after 11½ years of a tumour treated by orchidectomy and irradiation.

CONCLUSIONS

1. The quantitatively adapted Aschheim-Zondek test in cases of malignant disease of the testicle has considerable value.

2. There is need for a standardized technique, embracing many improvements suggested in the literature. These refer to extraction of the hormone; exclusion of renal factors by taking 24-hour specimens; routine assay before treatment and serially during and after treatment; use of more than one mouse per level of concentration; further inquiry into the nature and effects of the urinary hormones with a view to obtaining uniformity of interpretation of the test; histological section of the mouse ovary after the test; bioassay of the tumour itself and estimation of the two hormones separately if such duality can be confirmed.

3. The limitations of the test hitherto are based mostly on the lack of the above uniformity of technique. It is thus to be expected that the collected figures in *Table I* show considerable overlap and variation. It must not, however, be expected that clear-cut definition of the three main types of tumour will be forthcoming on a hormonal basis. Variations must occur where there are differences in the bulk of the primary and when there are metastases. Again, the enormous variation in the histiopathology of the embryonal teratoma group cannot make for uniformity in quantitative hormone output.

4. The figures collected show that over a large number of cases the range of titre is characteristic for each of the three main groups—the 'embryonal teratoma', the 'seminoma', and the 'mixed adult teratoma', benign or malignant; but that the precise pathology of a particular tumour cannot be predicted from the pre-operative urinary assay. All that can be said is that high levels tend to suggest the more embryonic-cell type, while low levels suggest either the seminoma or the mixed adult type.

Serial tests during and after treatment are of value in that they may indicate satisfactory progress, local recurrence, or the advent of metastases. Such tests should be performed for at least ten years after treatment, first weekly, then gradually becoming less frequent, till an interval of not more than six months separates two consecutive tests.

SUMMARY

Most of the available literature on the subject of hormonal tests in tumours of the testis has been reviewed.

The nature and limitations of the test have been discussed, with some suggestions for improvement and standardization. There is need for much more work to be done on the subject. The results of the

Aschheim-Zondek test in the hands of various workers have been collected and tabulated in over 300 cases.

An attempt has been made to subdivide the tumours into three main groups.

Prognosis and treatment have been briefly discussed.

I am indebted to the Medical Director-General of the Navy for permission to publish this paper, and record my sincere thanks to Mr. A. E. Roche, Dr. R. Welsh, and Professor Silverstein for reading the manuscript and providing helpful suggestions and criticism.

BIBLIOGRAPHY

BEILLY, KURLAND, and JACOBI (1940), *Endocrinology*, **26**, 965.
BONN and EVANS (1942), *Amer. J. Surg.*, **58**, 125.
CABOT, H., and BERKSON (1939), *New Engl. J. Med.*, **202**, 192.
CUTLER and OWEN (1935), *Amer. J. Cancer*, **24**, 318.
DEAN, personal communication, cited by FERGUSON, 1934.
FERGUSON, R. S. (1933), *Amer. J. Cancer*, **8**, No. 2.
— — et al. (1931), *Amer. J. Surg.*, April, 835.
FERRIS, D. O. (1943), *Clinics*, **1**, No. 5.
FORTNER and OWEN (1935), *Amer. J. Cancer.*, **25**, 89.
FRANK, R. T. (1943), *J. Mt. Sinai Hosp.*, May–June, **1**.
FREED and COPPOCK (1935), *Proc. Soc. exp. Biol., N.Y.*, **32**, 1589.
HAMBURGER et al. (1936), *Acta path. microbiol. Scand.*, **13**, 75.
HERGER and THIBANDEAR (1943), *Amer. J. Cancer*, **22**, 525.
HIGGINS and BUCHERT (1939), *Amer. J. Surg.*, **43**, 675.
HINMAN (1933), *Surg. Gynec. Obstet.*, **56**, 450.
— and POWELL (1935), *J. Urol.*, **34**, 55.
— — (1938), *J. Amer. med. Ass.*, Jan., 15.
MCDONALD (1938), *Amer. J. Cancer*, **34**, 1.
MCDOUGALL and GRAHAM (1943), *West. J. Surg.*, **51**.
OWEN, S. E. (1934), *J. Lab. and clin. Med.*, **20**, 296.
— — and CUTLER (1936), *Amer. J. med. Sci.*, **192**, 61
— — — (1937), *Med. Bull. Adm.*, **14**, 1.
PAYNE, R. (1938), *Lancet*, **1**, 364.
POWELL, T. O. (1938), *J. Urol.*, **39**, 522.
READ, JANE (1939), *Wisconsin med. J.*, **38**, 456.
ROCHE, A. E. (1933), *Proc. R. Soc. Med.*, **26**, 1063.
ROSENBLATT et al. (1942), *Amer. J. Surg.*, **57**, 94.
ROTTINO, A., and DE BELLIS, H. (1944), *Arch. Path.*, Jan.
STEVENS, W. E. (1940), *J. Urol.*, **44**, 864.
TANNER (1922), *Surg. Gynec. Obstet.*, **35**, 565.
TWOMBLEY, TEMPLE, and DEAN (1942), *J. Amer. med. Ass.*, **118**, 106.
YOUNG (1926), *Practice of Urology*, **1**, 611.
ZERMAN, P. (1943), *Med. J. Aust.*, **2**, 315.
ZONDEK (1930), *Chirurg.*, **2**, 1072.

CHRONIC HYPERTROPHIC ILEOCÆCAL TUBERCULOSIS, AND ITS RELATION TO REGIONAL ILEITIS (CROHN'S DISEASE)

BY A. W. TAYLOR

ALTHOUGH there are earlier references to chronic granulomata of uncertain aetiology affecting the intestine in man, recent interest in the subject was aroused by a paper by Crohn, Ginsberg, and Oppenheimer, in 1932, in which these authors described a chronic inflammatory lesion of non-tuberculous origin affecting the terminal ileum, termed by them 'regional ileitis'. Since Crohn's original description, a voluminous literature, mainly in America and this country, has sprung up around the subject, and by 1937 over 200 cases had been recorded in America alone. Although Crohn originally described the disorder as affecting the terminal ileum, subsequent writers, and later Crohn himself, have recognized that the cæcum and ascending colon may also be involved. Crohn and most subsequent writers have insisted that regional ileitis is distinguishable clinically and pathologically from hypertrophic ileocæcal tuberculosis, and it is this claim which it is here intended to examine.

Turning to hypertrophic ileocæcal tuberculosis, we come to a clinical and pathological entity which has been recognized for many years. Here is no 'new disease', as regional ileitis has been termed (Barrington-Ward, 1938), but one which has become outmoded by its new and popular rival. So much so, indeed, that a leading text-book of general medicine states categorically that there is no evidence that this disease is tuberculous in origin, and that it is probably a form of regional ileitis (Price, 1941). Although not all modern opinion on the subject is quite as dogmatic as this, the increasing tendency is to view with suspicion any diagnosis of hypertrophic ileocæcal tuberculosis.

Clinically, the two conditions have much in common. The age incidence is the same. Graham (1941), in a series of 35 cases of regional ileitis, showed that 74·3 per cent occurred in patients under 40, while Stewart (1927), in his series of 21 cases of hypertrophic ileocæcal tuberculosis, found that 80·9 per cent occurred in the same age group.

The clinical features of abdominal pain with nausea and vomiting, low-grade pyrexia, palpable mass in the right iliac fossa, obstructive symptoms, and finally sinus formation, are common to the two diseases. Both diseases commonly result in the presence of occult, and, rarely, fresh blood in the stools, Radiologically distinction is not possible, since, as will be seen, the intestinal lesions are indistinguishable, and therefore the mechanical effects are the same.

AETIOLOGY

Nothing certain is known of the aetiology of regional ileitis, and little is to be gained by recapitulating the numbers of almost entirely theoretical possibilities put forward by various authors. Of the more plausible suggestions, one may mention the dysenteric theory put forward by Felson (1935), who claimed to have isolated dysenteric organisms from the lesions, and to have demonstrated diagnostic agglutination titres in a series of cases. No subsequent investigation has confirmed these findings.

Reichert and Mathes (1936) in interesting experiments, using dogs as experimental animals, showed that the injection of sclerosing material into the mesenteric lymphatics will produce a chronic lymphœdema of the affected intestinal segment, with little or no tendency to resolution, and an associated hypertrophy of the muscle layers. There was, however, no associated inflammatory reaction, and no tendency to ulceration of the mucosa.

Bockus and Lee (1935) suggest that some anatomical peculiarity of the ileocæcal region may predispose to the development of chronic inflammatory lesions in this region from a variety of causes, all of which might give rise to a similar clinical picture.

Hadfield (1939) sees in the histology of the lesions a possible relationship to the equally mysterious sarcoidosis of Boeck. A tuberculous aetiology has by earlier writers been rejected, often without any evidence whatever, but more recently it has been shown (Pumphrey, 1938) that where a series of cases of regional ileitis is thoroughly investigated it is found that up to 20 per cent are proven tuberculous by careful histological examination and animal inoculation. With hypertrophic ileocæcal tuberculosis we are on surer ground; the histology is frankly tuberculous, although as Stewart (1927) emphasizes, it may be necessary to examine sections from several blocks before finding characteristic tubercles. Tubercle bacilli may be found in the lesions by appropriate staining methods, by culture, or by animal inoculation.

PATHOLOGY

The macroscopical pathology of Crohn's disease and of hypertrophic ileocæcal tuberculosis resemble each other so closely that one description will suffice. The lesion affects the terminal ileum and commonly involves the cæcum and ascending colon. The essential lesion is seen in the chronic inflammation and thickening of the intestinal wall, resulting in stenosis of the affected gut. There is usually an associated ulceration of the mucous membrane and often a mesenteric lymphadenitis. In the case of hypertrophic ileocæcal tuberculosis, there may or may not be obvious subperitoneal tubercles over the affected gut, but as small subperitoneal nodules of similar appearance due to lymphoid collections or fibrous nodules may occur in Crohn's disease, the point is not of diagnostic value.

The histological picture of Crohn's disease is said to be that of a proliferative subacute or chronic inflammation: most authors stress the lymphoid overgrowth, with its many follicles, the germinal centres of which tend to be extremely hyperplastic: added to this, there is always diffuse infiltration of all the layers of the thickened intestinal wall by eosinophils, lymphocytes, plasma cells, mononuclears, and polymorphs in varying proportions. Foreign-body giant cells are occasionally seen. As to the presence or absence of true tubercles, there is a remarkable lack of agreement in published reports. In a review of 21 cases from the Mayo Clinic, Coffey (1938) states that true tubercles are not seen in Crohn's disease and that their presence should suggest a tuberculous aetiology. On the other hand, in the case reported by Colbeck, Hurst, and Lintott (1937), the histology is reported as being indistinguishable from tuberculosis.

Hadfield (1939) stresses the resemblance of the hypertrophied lymph follicles to the similar appearances seen in Boeck's sarcoidosis. The histology of hypertrophic ileocæcal tuberculosis is well known; every characteristic of tuberculous lesions is seen, and the only points worth bringing out are that caseation is not usually a prominent feature, and that the ratio of tuberculous to non-specific inflammatory change varies enormously from case to case. Stewart (1927) has pointed out that the whole affected gut wall may show no evidence of tuberculosis, but that related mesenteric lymph-glands may show active tuberculous disease.

CASE REPORTS

Case 1.—A man, aged 52 years, gave a history of lower abdominal pain over the previous 14 years, becoming more severe and spasmodic in nature during the past few weeks. There was a recent history of increasing constipation and some loss of weight.

On examination, a palpable tumour was felt over the line of the ascending colon. Fæcal examination showed occult blood present. X-ray examination showed a filling defect of the cæcum.

At operation (Nov. 17, 1943, Mr. E. C. Hughes) the terminal ileum and cæcum were found thickened and inflamed, with tubercles on the peritoneal surface. The affected ileum, the cæcum, and ascending colon were excised and an end-to-end anastomosis made between ileum and transverse colon.

After operation, signs and symptoms of pulmonary tuberculosis appeared, and death from pulmonary tuberculosis occurred three months later. Autopsy was not performed. The resected gut showed much thickening and stenosis, with diffuse ulceration of the mucous membrane. Sections showed extensive tuberculous infiltration, with tubercle bacilli present.

Case 2.—A woman, aged 21 years, was admitted on account of a severe attack of pain in the right iliac fossa. She had had similar attacks, usually associated with vomiting, during the previous year. A diagnosis of acute appendicitis was made, and at operation (April 23, 1943, Mr. J. J. Bell) the terminal ileum, cæcum, and appendix were found to be bound down by adhesions: thickening and inflammation were seen, and tubercles were present on the peritoneal surface. The appendix was removed, and on section showed widespread infiltration of all its layers by typical tuberculous granulation tissue. Subsequent X-ray examination showed a filling defect of the cæcum and a loop of small gut adherent to the ascending colon. Radiography of the chest showed suspicious mottling at the left apex.

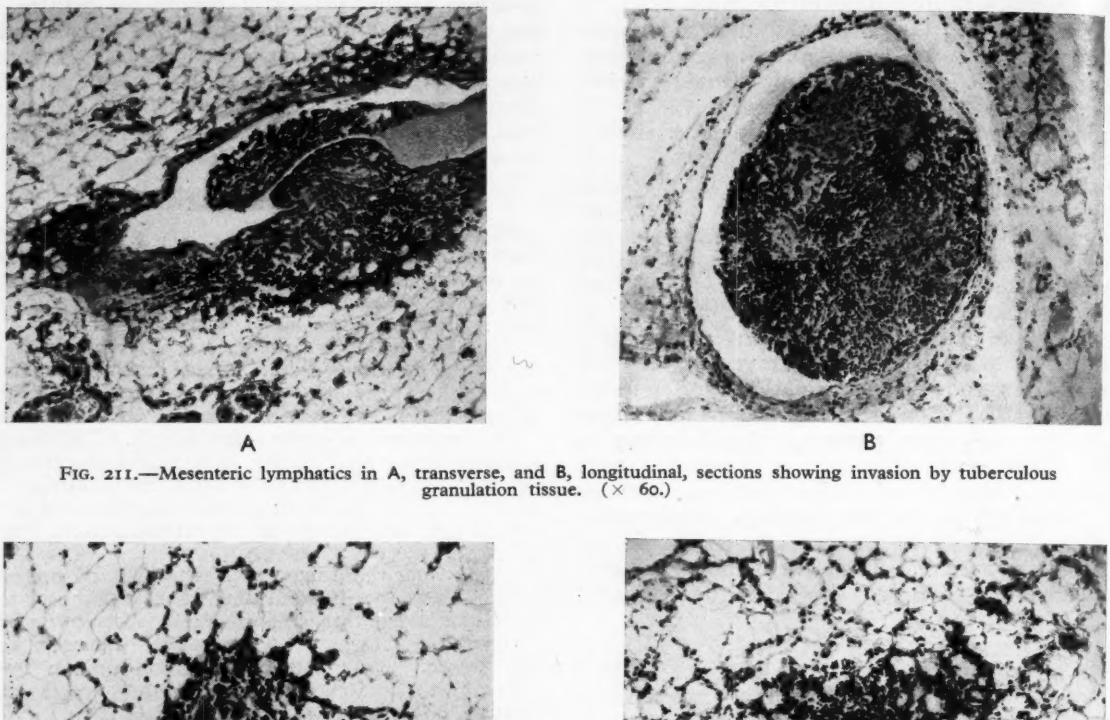
The patient was discharged four months later in good condition. She was readmitted four months later still with recurrence of abdominal pain and a general deterioration of her general condition, and died July 5, 1944.

At autopsy, a generalized miliary tuberculosis was found. An old quiescent tuberculous focus was present at the apex of the left lung. The lower ileum showed an acute tuberculous ulceration: in addition, hypertrophic ileocæcal tuberculosis affecting the terminal ileum, cæcum, and ascending colon was found, with multiple adhesions and a small loculated area of tuberculous peritonitis.

Histological examination confirmed these findings. Tubercle bacilli were present in the lesions.

Case 3.—A girl, aged 15 years, was admitted on account of swelling of the left knee and left wrist. She gave a history of attacks of abdominal pain during the month before admission.

While in hospital the joint condition subsided, but she suffered from a low-grade pyrexia, and the attacks of abdominal pain, usually peri-umbilical in position, became more severe and frequent. A palpable mass was found in the right iliac fossa and X-ray examination showed a filling defect of the terminal ileum. The fæces showed occult blood present. Mantoux test was negative in 1–100.



A B

FIG. 211.—Mesenteric lymphatics in A, transverse, and B, longitudinal, sections showing invasion by tuberculous granulation tissue. (× 60.)

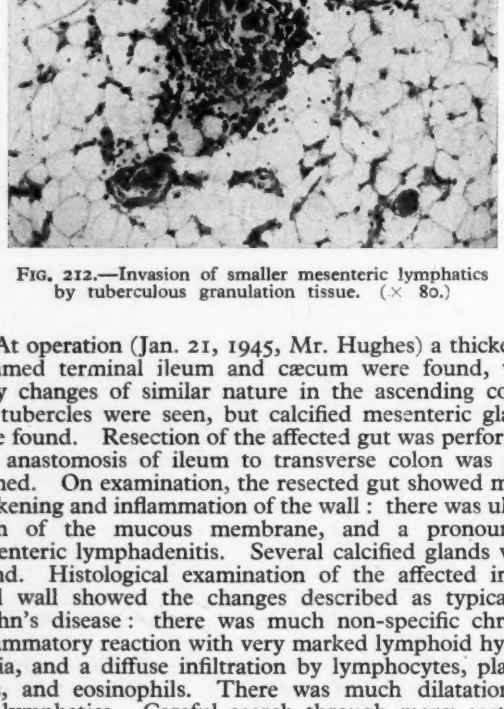


FIG. 212.—Invasion of smaller mesenteric lymphatics by tuberculous granulation tissue. (× 80.)

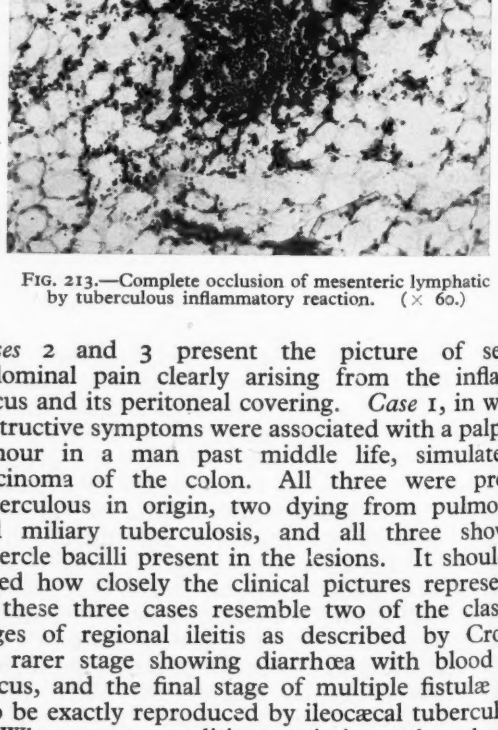


FIG. 213.—Complete occlusion of mesenteric lymphatic by tuberculous inflammatory reaction. (× 60.)

At operation (Jan. 21, 1945, Mr. Hughes) a thickened inflamed terminal ileum and cæcum were found, with early changes of similar nature in the ascending colon. No tubercles were seen, but calcified mesenteric glands were found. Resection of the affected gut was performed and anastomosis of ileum to transverse colon was performed. On examination, the resected gut showed much thickening and inflammation of the wall: there was ulceration of the mucous membrane, and a pronounced mesenteric lymphadenitis. Several calcified glands were found. Histological examination of the affected intestinal wall showed the changes described as typical of Crohn's disease: there was much non-specific chronic inflammatory reaction with very marked lymphoid hyperplasia, and a diffuse infiltration by lymphocytes, plasma cells, and eosinophils. There was much dilatation of the lymphatics. Careful search through many sections showed occasional typical tubercles with endothelial cell reaction and giant cells present. Section of areas of the mesentery showed a striking lymphangitis, apparently tuberculous in nature (*Figs.* 211–213). Tubercle bacilli were found in areas of tuberculous granulation tissue in the mesentery.

DISCUSSION

The three cases reported above exemplify clinical pictures associated with ileocæcal tuberculosis:

Cases 2 and 3 present the picture of severe abdominal pain clearly arising from the inflamed viscus and its peritoneal covering. *Case* 1, in which obstructive symptoms were associated with a palpable tumour in a man past middle life, simulated a carcinoma of the colon. All three were proven tuberculous in origin, two dying from pulmonary and miliary tuberculosis, and all three showing tubercle bacilli present in the lesions. It should be noted how closely the clinical pictures represented by these three cases resemble two of the classical stages of regional ileitis as described by Crohn; the rarer stage showing diarrhœa with blood and mucus, and the final stage of multiple fistulæ may also be exactly reproduced by ileocæcal tuberculosis.

Where two conditions mimic each other as closely as do these, clinical differentiation is clearly not possible, and this is not surprising since the

basic pathology is identical, giving the successive stages of inflammation and local peritonitis, ulceration of the mucous membrane, fibrosis, thickening, and stenosis of the affected gut, and finally fistula formation. The histological features of the three cases described above are of some interest; the first two were frankly tuberculous and tubercle bacilli were numerous in the lesions. There was, however, also much non-specific inflammatory reaction, and lymphoid hyperplasia with irregularly distributed follicles was also present. Considerable dilatation of the lymphatics was a striking feature. In the third case the picture was entirely different. Here chronic non-specific inflammatory changes with great lymphoid hyperplasia made up almost the whole picture in the affected gut wall. Again dilated lymphatics were prominent. But prolonged search revealed a very few typical tubercules with endothelial cells and scattered giant cells. Examination of the mesentery of the resected gut showed the picture of an advanced lymphangitis, with lymphatic channels occluded by tuberculous granulation tissue, ringed by lymphocytes, or completely replaced by fibrous tissue: in fact, inflammatory changes were, in the mesentery, entirely restricted to the lymphatics, and their tuberculous nature was much more evident in this site than in the gut wall. It was only in the mesentery that tubercle bacilli were demonstrated.

It is suggested that in this observation there is a clue to the nature of Crohn's disease. Reichert and Mathes (1936) showed that the hypertrophied gut wall is explicable on the basis of lymphatic obstruction in the affected segment. Maintenance of the obstruction, with the pronounced secondary inflammatory reaction, may well be caused by a low-grade tuberculous infection largely restricted to the lymphatic system, perhaps because of a high degree of tissue immunity. Where resistance is low, the tuberculous infection spreads diffusely throughout the gut wall, giving the picture of a florid ileocæcal tuberculosis. The two conditions of Crohn's disease and hypertrophic ileocæcal tuberculosis thus are probably different reactions of the human host to a single disease, and grade into each other.

Finally, let us examine the bacteriological side of this question. As was seen earlier, since neither clinical nor pathological criteria enable distinction to be made, it is only after a failure to detect tubercle bacilli in the lesions that a case should be labelled Crohn's disease. This has been admitted in a summary of the subject by Lintott (1938). Unfortunately, it is only in a small minority of recorded cases that this essential criterion has been applied. Technically the finding of tubercle bacilli in stained sections of tuberculous lesions is not always easy, and while a positive result is conclusive, a negative by no means excludes a tuberculous pathology. Animal inoculation is a more accurate test, but is not infallible, and in a study of the literature one is usually given no information as to the amount or nature of the tissue used, its preparation before inoculation, or the number of animals inoculated.

Where animal inoculation gives negative results, are we justified in stating that the lesion is certainly non-tuberculous? *Case* 3 in this series shows how scanty may be the tuberculous granulation tissue in the lesion and how it may largely be restricted to the mesenteric lymphatics; these features may be due in part to tissue resistance of the host and perhaps also to an attenuated tubercle bacillus which may not possess normal pathogenicity. The final stage may well be reached when the tuberculous lymphangitis has burnt itself out, leaving a thickened, scarred intestinal wall, obliterated mesenteric lymphvessels, and the secondarily hypertrophied lymphoid tissue. Secondary infection of this deformed segment of gut is inevitable. It is thus quite understandable that in a proportion of cases of hypertrophic ileocæcal tuberculosis the lesions may show no evidence of a tuberculous aetiology.

It seems probable that Crohn's disease has had, as a new disease, too enthusiastic and uncritical a reception, and that hypertrophic ileocæcal tuberculosis has been too lightly discarded as a clinical and pathological entity. Tuberculosis, though not always of florid type, probably accounts for a much higher percentage of cases of regional ileitis than is at present recognized.

SUMMARY

1. A review is given of the aetiology, pathology, and histology of Crohn's disease and hypertrophic ileocæcal tuberculosis.

2. Attention is drawn to the fact that it is impossible on a basis of clinical features or morbid anatomy to distinguish between the two conditions.

3. Three cases of hypertrophic ileocæcal tuberculosis are described.

4. A chronic tuberculous mesenteric lymphangitis is described in one of these cases: the wall of the affected ileum in this case showed the gross pathological and the histological features described as characteristic of Crohn's disease.

5. It is suggested that a similar chronic tuberculous lymphangitis of the mesentery may be the basis of many cases of regional ileitis where the lesions in the affected gut wall are apparently non-tuberculous.

REFERENCES

BARRINGTON-WARD, SIR L., and NORRISH, R. E. (1938), *Brit. J. Surg.*, **25**, 530.
BOCKUS, H. L., and LEE, W. E. (1935), *Ann. Surg.*, **102**, 412.
COFFEY, R. J. (1938), *Proc. Mayo Clin.*, **13**, 541.
COLBECK, J. C., HURST, A. F., and LINTOTT, G. A. M. (1937), *Guy's Hosp. Rep.*, **17**, 178.
CROHN, B. B., GINSBERG, L., and OPPENHEIMER, G. D. (1932), *J. Amer. med. Ass.*, **99**, 1323.
FELSEN, J., and GORENBERG, H. (1936), *Amer. J. med. Sci.*, **192**, 553.
GRAHAM, W. L. (1941), *Canad. med. Ass. J.*, **44**, 168.
HADFIELD, G. (1939), *Lancet*, **2**, 773.
JACKSON, A. S. (1937), *Surg. Gynec. Obstet.*, **65**, 1.
LINTOTT, G. A. M. (1938), *Brit. Encycl. Med. Pract.*, **7**, 253.
PUMPHREY, R. E. (1938), *Proc. Mayo Clin.*, **13**, 539.
REICHERT, M. L., and MATHES, M. E. (1936), *Ann. Surg.*, **104**, 601.
STEWART, M. (1928), *Tubercle*, **9**, 409.

SHORT NOTES OF RARE OR OBSCURE CASES

INTUSSUSCEPTION OF THE SIGMOID DUE TO SIMPLE POLYPUS WITH ANNULAR CARCINOMA OF THE DESCENDING COLON

By B. T. ROSE, Birmingham

CASE REPORT

History.—J. L., aged 70, was seen with symptoms of subacute obstruction of three days' duration, associated with the passage of blood and mucus per rectum. An elongated tumour could be felt in the left iliac fossa, while per rectum a rounded swelling the size of a bantam's egg could be just reached with the finger.

A diagnosis of intussusception of the sigmoid due to polypus was made.

Operative Findings.—An intussusception of the whole of the sigmoid loop about 10 in. in length was found. At the apex a large polypus could be felt. The intussusception was almost reduced with considerable difficulty, when it was noted that an annular carcinoma of the colon was present just below the splenic flexure (*Fig.* 214). The sigmoid, descending colon, and splenic flexure were mobilized and resected by Paul's method.

Fig. 214.—Showing the intestine, which has greatly shrunken in preservation, and the incompletely reduced intussusception with the polypus and the adenocarcinoma of the colon. (*Approximately one-half natural size.*)

COMMENT

The association of multiple polypi with carcinoma of the colon is well known, but the single polypus in the writer's experience is also not infrequently found with a new growth of the colon.

I am indebted to Mr. W. J. Pardoe, of Birmingham, for the illustration.

DISCOLORATION OF THE ABDOMINAL WALL IN ACUTE PANCREATITIS

By H. T. COX

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This condition was first observed by Grey Turner in 1912 and published in 1920. Cullen in America both observed and published in 1918 an account of the umbilical discoloration in ruptured ectopic gestation. In English literature the terms Grey Turner's and Cullen's signs refer respectively to the condition each first described, while in American literature the term Cullen's sign includes both conditions.

The illustration of umbilical and flank discoloration (*Fig.* 215) was drawn from a case of acute pancreatitis on the ninth day of the disease.

CASE REPORT

A female, aged 65, was admitted to Withington Hospital, Manchester, Dec. 14, 1943, with upper abdominal pain of 16 hours' duration. The pain was sudden in onset, continuous, intense, with maximum localization between the umbilicus and left costal margin, and radiating to the left costovertebral angle. Pulse 104, temperature 97°. Previous history: Gastrojejunostomy (duodenal ulcer) and appendicectomy, July, 1926.

On the third day of the disease a discoloured area appeared on the skin around the umbilicus; on the seventh day a similar but smaller area was first noticed in the left flank. These areas, lacking uniformity in colour and showing an admixture of distinct blue, green, and yellow elements, resembled exactly the colour changes in a fading ecchymosis. A diagnosis of acute pancreatitis was made. Urinary diastatic index 12; 6600 units in 24 hours. Serum lipase 0·35 units.

On conservative treatment the signs and symptoms diminished in intensity with the formation of a well-localized mass in the left hypochondrium. This mass was drained through a small incision over it. Both oblique and transversus muscles were found to be

permeated with dark red blood. On incising these structures a cavity containing 3 oz. of blood-clot was immediately entered. A rubber tube was inserted. Pathological report on the blood-clot: "Blood-clot shows increased lipase activity. Inoculation of clot into ethyl butyrate hydrolyses five times as much as is hydrolysed by normal clots". The convalescence was uneventful.

DISCUSSION

The discoloured areas have been variously reported as bluish, dirty-greenish, and yellow. Fallis (1937), amongst others, suggests that the discoloration resembles an ecchymosis in that the colour is at first blue-black, then green, and finally yellow before disappearing.

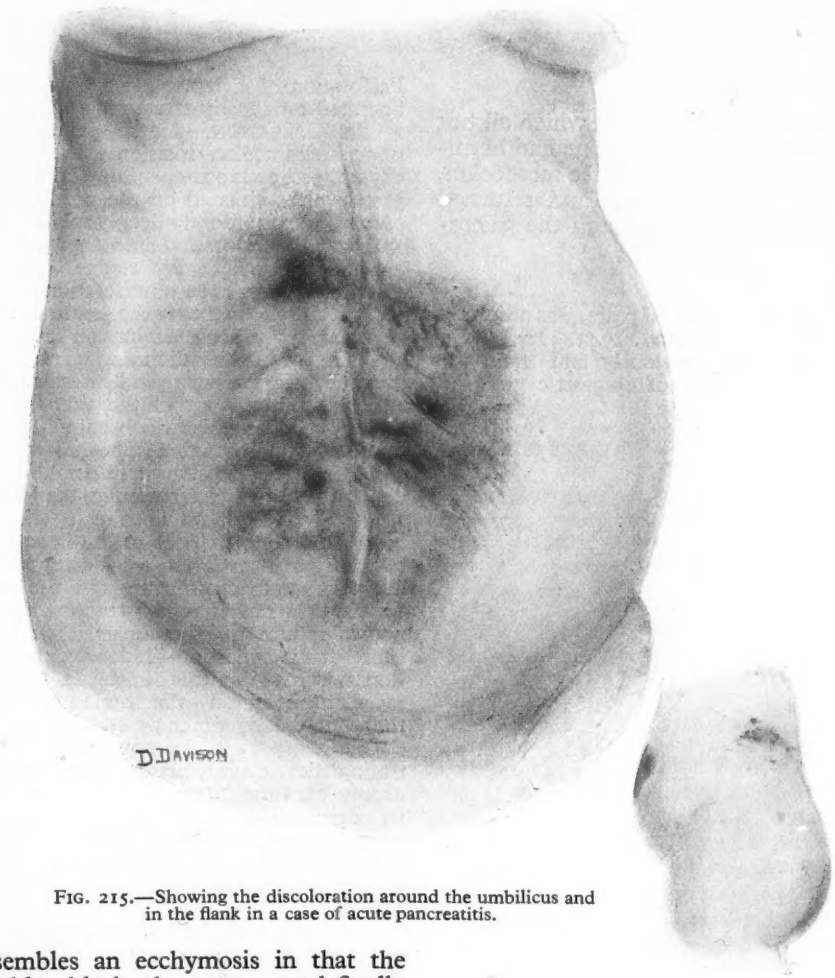

FIG. 215.—Showing the discoloration around the umbilicus and in the flank in a case of acute pancreatitis.

The importance of the sign lies in the diagnostic value; its interest in its aetiology. The flank discoloration is universally agreed to be due to direct extraperitoneal spread of blood and pancreatic secretion. The umbilical discoloration, however, has offered scope for much ingenuity in attempts at explanation, some of which are of extremely doubtful validity and anatomy. Grey Turner (1920) refers to the possibility of pancreatic secretions arriving at the umbilicus via the round ligament, while Fallis (1937) suggests abnormal apertures in the peritoneum, the rich anastomosis between the lymphatics of the subcutaneous tissue and those of the peritoneum, and finally an extraperitoneal method of spread. The last is described as being limited above and below the umbilicus by the suspensory ligament and urachus respectively, with a consequent tendency to pool in the potential subumbilical space where there is direct contact with the subcutaneous tissue owing to the absence of the fascia transversalis. Fallis has described 2 cases of acute pancreatitis with umbilical discoloration but without a blood-stained peritoneal exudate—strong evidence, to which this case adds further support, in favour of the extraperitoneal method of spread.

The incidence of umbilical discoloration is rare. This may be due to a pathological variation in the disease or to an anatomical variation at the umbilicus. Poirier (1912) describes the existence of a structure, the umbilical fascia. This is a thickening of the transversalis fascia. Levadoux (quoted by Poirier) observed it in 84 per cent of adults. Typically it completely or partially covers, and is firmly applied to, the umbilical ring. It may, however, more rarely occur as a band about the thickness of a finger, well above the umbilicus. In those cases in which the umbilical fascia does not constitute a complete covering for the umbilical ring, there is direct continuity at the umbilicus between the

extraperitoneal and subcutaneous tissues. This arrangement clearly favours umbilical spread of retroperitoneal changes.

It is a rational assumption that this anatomical variation in the presence of a retroperitoneal spread is one deciding factor in the development and incidence of umbilical discoloration in acute pancreatitis.

I am much indebted to Professor Wood Jones for the anatomical reference.

REFERENCES

CULLEN, T. S. (1918), *Amer. J. Obstet. Gynec.*, **78**, 457.
FALLIS, L. S. (1937), *Ann. Surg.*, **106**, 54.
POIRIER, P. and CHARPY (1912), *Traité d'Anatomie humaine*, vol. 2, pt. 1, 354.
TURNER, G. G. (1919–20), *Brit. J. Surg.*, **7**, 394.

HERNIA TRAVERSING THE LESSER SAC

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CASE REPORTS

THE first case to be described is one in which all but the terminal few inches of small intestine had herniated through an aperture in the transverse mesocolon, across the lesser sac of peritoneum, and returned to the general peritoneal cavity through the gastro-hepatic omentum.

Case 1.—

HISTORY.—J. W. A., male aged 56 years, was admitted to St. James's Hospital on March 27, 1943. He gave a history of having four years previously and again for the last three weeks had attacks of epigastric gnawing pain two and a half hours after meals, relieved by taking food. Five hours before admission he was suddenly seized with a violent generalized abdominal pain. Just prior to the onset of pain he had vomited altered blood, but had not vomited since.

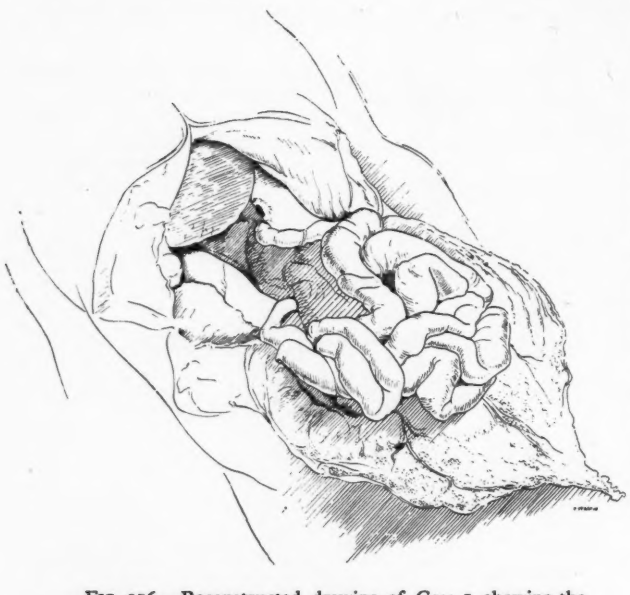

FIG. 216.—Reconstructed drawing of *Case* 1, showing the abnormal presentation of the small bowel in front of the stomach and colon.

ON EXAMINATION.—He was pale and appeared to be in obvious pain and very shocked. The temperature was subnormal, pulse-rate 100 and of irregular rhythm, and the respiration-rate 20. The respirations were entirely thoracic. There were moist sounds at the base of the right lung; the heart-sounds were distant and irregular. The abdomen was of board-like rigidity and very tender all over. Normal liver dullness was present. Perforation of a peptic ulcer was diagnosed and he was operated on shortly afterwards.

AT OPERATION.—Under general anæsthesia a right upper paramedian incision was made. Free gas and chyme escaped on opening the peritoneal cavity. A gastric ulcer situated on the posterior part of the lesser curvature was found, deeply penetrating the pancreas, and with a perforation into the peritoneal cavity about 1 cm. diameter at its lower edge. It was now noted that this would have been a perforation confined to the lesser sac but for the fact that the gastro-hepatic omentum was deficient. Further examination revealed the surprising appearance of the small intestine and its mesentery passing over the lesser curvature and anterior surface of the pyloric antrum, so that part of the stomach, transverse colon, and great omentum were obscured by it (*Fig.* 216). The duodenojejunal junction appeared to be pulled high up and there were adhesions in its neighbourhood. The distal ileum was seen to pass back over the lesser curvature of the stomach, through an opening in the transverse mesocolon, and then straight to the ileocæcal valve, this part of the bowel appearing a little tense. The cæcum was drawn towards the opening in the mesocolon. There was no evidence of any obstruction and so it was decided not to reduce this hernia as it was obviously not the cause of his condition—indeed, only a cursory examination was made at this time. In view of the history of recent hæmatemesis, the whole ulcer was separated from the pancreas by pinching it with the fingers, the ulcer edge trimmed, and the now very wide completely penetrating ulcer closed, first with interrupted sutures placed deeply with the intent of obliterating any open vessel in its edge, and then by a second continuous seromuscular suture placed over this. After aspirating the peritoneal fluid a drainage tube to the pelvis was inserted through a suprapubic stab wound and the abdomen closed in layers.

PROGRESS.—An intravenous saline and plasma drip was given after the operation. For two days the patient made normal progress, but then signs of general peritonitis and circulatory failure became evident and he died on March 30.

AT AUTOPSY.—On March 31 Dr. Allen P. Piggot made a post-mortem examination. No cardiovascular abnormality was found apart from a few patches of aortic atheroma. There were patches of bronchopneumonia in both lungs.

Examination of the peritoneal cavity revealed a plastic general peritonitis. In the stomach was an ulcer 3 in. by 2 in., oval in shape, with two thrombosed vessel ends in its base. The sutures closing the perforation were intact. The site of pancreatic ulceration was noted.

The whole of the small intestine from duodenojejunal junction to just over three inches from the ileocæcal valve passed through a smooth-edged opening in the transverse mesocolon to the left of the middle

colic vessels, under the colic arch and 4 in. by 3 in. in diameter. The small intestine and its rather abnormally long mesentery passed behind the stomach, over its lesser curve and through a wide defect in the gastrohepatic omentum and down in front of the pyloric antrum and colon. One coil of bowel was adherent to the site of the gastric perforation and all was covered with fibrinous exudate. There was no evidence of any intestinal obstruction.

The second case to be described, which followed a posterior gastrojejunostomy, is one in which the whole of the small intestine from stoma to within a few inches of the ileocæcal valve had herniated through the transverse mesocolon, across the lesser sac, and returned to the general peritoneal cavity through an opening on the left of the gastrocolic omentum.

Case 2.—

HISTORY.—J. M., male aged 61 years, was admitted to St. James's Hospital on March 1, 1945. He gave a history of dyspepsia since 1923. In 1928 he had a gastrojejunostomy performed for duodenal ulcer at a London hospital. For six months after this operation he had repeated attacks of vomiting, but these gradually diminished in severity and he attained some degree of comfort. About 1938 he began to develop periodic bouts of pain in the right hypochondrium, worse at night, on stooping, or after meals. There was some relief by taking alkaline powders. He had a course of medical treatment for this in June, 1944. Just prior to admission he had had very severe pain.

ON ADMISSION.—He was fairly well nourished. Examination of the abdomen disclosed a well-healed right paramedian scar, and tenderness on palpation just below the umbilicus.

On gastroscopic examination, the gastroscope entered a posterior gastrojejunostomy stoma, and an ulcer was seen on its margin.

Radiography of a barium meal showed a deformed duodenum and deformity in the region of the stoma. Much of the barium left via the duodenum and it was seen that the jejunum immediately proximal to the stoma was very dilated.

Surgical treatment was considered advisable, and when the patient's general condition appeared to be at its best, operation was undertaken.

AT OPERATION.—Under local and light cyclopropane anæsthesia, the right paramedian incision was re-opened and a moderate number of adhesions were divided. A remarkable appearance was now seen (*Fig.* 217). There was an opening to the left of the gastrocolic omentum through which the dilated afferent loop of a posterior gastrojejunostomy could be seen, which was rather high up the body of the stomach and near its greater curve. On the gastrojejunostomy was seen a congested scar. The efferent loop of the anastomosis passed forwards through the opening in the gastrocolic omentum and then down in front of the colon and great omentum. It was several moments before it was realized that nearly the whole of the small bowel was herniated through this opening and the afferent loop of the herniated bowel passed up behind the efferent loop and through the gastrocolic omentum opening, through lesser sac and transverse mesocolon, straight to the ileocæcal valve. The edge of the opening in the transverse mesocolon was only partly adherent to the small bowel and not at all to the stomach.

Further examination showed stenosing inactive anterior and posterior duodenal ulcers with prestenotic diverticula.

The small bowel was now reduced through the lesser sac to its normal position. The gastrojejunostomy was undone and the jejunum repaired. The opening in the transverse mesocolon was closed. As it had been noted that the gastric mucosa was thick—and thus probably prone to recurrent ulceration—a high antecolic Hofmeister type of partial gastrectomy was performed, transecting

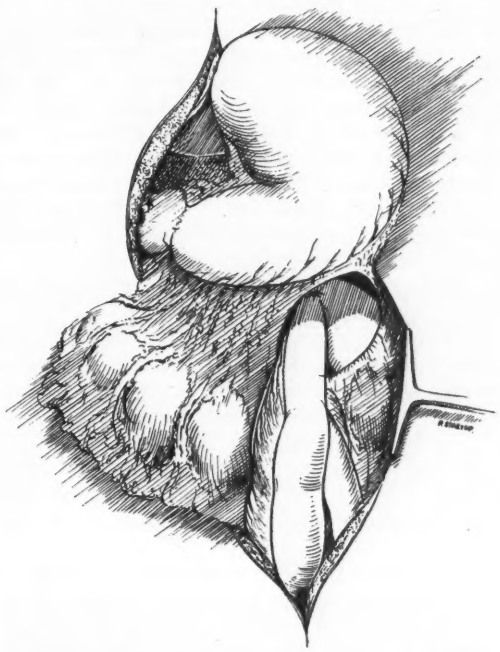

FIG. 217.—Reconstructed drawing of *Case* 2, showing the abnormal presentation of the small bowel in front of the colon and gastrocolic omentum.

the duodenum opposite the duodenal scars and anastomosing the stomach to jejunum well caudal to the site of the previous stoma. The abdomen was then closed.

The patient has made a good recovery from the operation.

COMMENTARY

In Rendle Short's series (1915; 1924) of internal herniæ only 17 passed through the transverse mesocolon.

The cause of herniation through the transverse mesocolon, excepting that type which follows surgically made openings in it, is uncertain. It is to be distinguished from the congenital hernia between the layers of the transverse mesocolon—that is, the true mesocolic hernia (recessus intermesocolicus transversus) (Moynihan and Dobson, 1906)—but Schwalbe (1904) and Chalmers (1905) suggest that it may result from this form by rupture of the division between mesocolic hernia and lesser sac. The general consensus of opinion is that it is acquired. It appears to the left of the middle colic vessels and under the colic vascular arch (such an opening has rarely been noted without any bowel going through it). In this region the mesocolon is tenuous and of poor blood-supply. Hernia through the transverse mesocolon into the lesser sac may follow the operation of posterior gastrojejunostomy, but it is now much less common than formerly as the importance of taking the precaution of suturing the margin of the opening in the mesocolon to the stomach is now universally appreciated (Mayo et al., 1940). It is possible that in the second case described this type of hernia was produced by a

rather high gastrojejunostomy performed in the presence of gastric distension, so that when the stomach became reduced in size with freer emptying the stoma was pulled upwards and with it the small bowel was pulled into the lesser sac.

In the event of bowel entering the lesser sac through the transverse mesocolon it may remain there—or pass between the leaves of the great omentum if these are incompletely fused. The bowel may, however, re-enter the peritoneal cavity by perforating the gastrohepatic omentum, the gastrocolic ligament just below the gastro-epiploic arch, or the great omentum. I can find no record of it re-entering by passing through the foramen of Winslow, though this seems a possibility.

Re-entrance to the general peritoneal cavity through the gastrohepatic omentum is very rare, but J. Hogarth Pringle (1919) described 2 such cases in his own practice and quoted 1 case operated on by W. J. Mayo. It is interesting in view of the perforated gastric ulcer and hæmatemesis in the first case here recorded to mention that Mayo's case also had a gastric ulcer, and both of Pringle's cases had a history of dyspepsia and hæmatemesis though no ulcer was found in the latter two at laparotomy.

As the gastrohepatic omentum is even more tenuous than the transverse mesocolon, it is not surprising that it is a route for the re-entrance of the bowel to the general peritoneal cavity, and herniæ which gain entrance to the lesser sac by the foramen of Winslow may leave it by this route (Edwards, 1943). An opening in the transverse mesocolon may also act as a route for re-entrance of bowel to the general peritoneal cavity, in cases where some other route of entry to the lesser sac is present.

It is possible that in the first case described the posterior ulcer may have attached itself at some stage to the transverse mesocolon, pulled it out in a diverticulum which became filled with small bowel, and later the diverticulum burst into the lesser sac. Occasionally a dimpling of the mesocolon is seen as a result of adhesion to a gastric ulcer. On the other hand, the dyspepsia or even the hæmatemesis may result from the hernia, for a history of dyspepsia is not unusual with hernia into the lesser sac no matter what route of entrance to it the bowel may take.

REFERENCES

CHALMERS, A. J. (1905), *J. Path. Bact.*, **10**, 287.
EDWARDS, H., and STEWART, W. (1943), *Brit. med. J.*, **1**, 343.
MAYO, C. W., MILLER, J. H., and STALKER, L. K. (1940), *Coll. Pap. Mayo Clin.*, **32**, 324.
MOYNIHAN, B. G. A., and DOBSON, J. F. (1906), *Retro-peritoneal Hernia*. London.
PRINGLE, J. HOGARTH (1919), *Glasg. med. J.*, **91**, 129.
SCHWALBE (1904), *Virchows Arch.* **177**, 561.
SHORT, A. RENDLE (1915), *Brit. J. Surg.*, **3**, 48.
— — (1924), *Ibid.*, **12**, 456.

CARCINOMA OF THE SMALL INTESTINES

BY B. T. ROSE, BIRMINGHAM

CASE REPORT

HISTORY.—A man of 59 years of age was admitted with a history of four months' colicky abdominal pain with occasional attacks of vomiting. Examination of the abdomen showed some distension with well-marked laddering and visible peristalsis over the whole abdomen. The large intestine did not appear to be distended.

A diagnosis of subacute intestinal obstruction was made, with the ileocæcal region as the probable site of the obstruction.

OPERATIVE FINDINGS.—At laparotomy an annular carcinoma of the jejunum was found 2 ft. from the duodenojejunal flexure. The small intestine above the growth was greatly dilated and hypertrophied, while below the obstruction dilatation and hypertrophy were also present for at least another 10 ft., gradually tailing off so that the lower ileum was of normal texture and size (*Fig.* 218). No other growth was found in the rest of the intestinal tract. Primary resection of some 10 in. of intestine was carried out with ease.

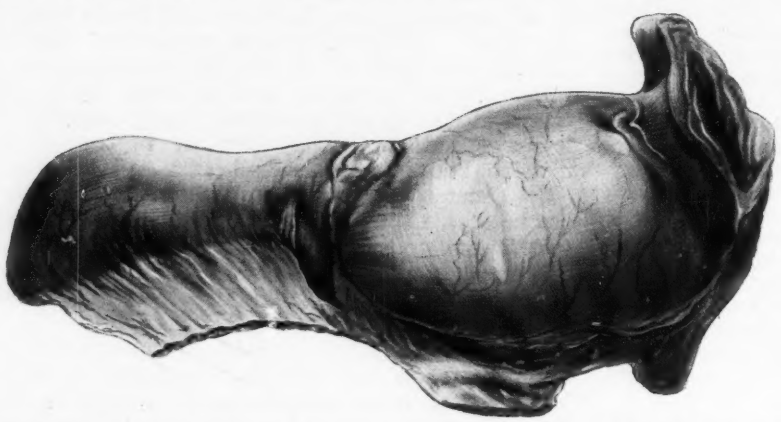

FIG. 218.—Showing the annular growth with dilated and hypertrophied intestine above and below it. (*Approximately one-half natural size.*)

Pathological examination showed the growth to be an adenocarcinoma with much interstitial fibrosis.

Comment.—Carcinoma of the small intestine is rare, but the curious feature in this case was the hypertrophy and dilatation below the obstruction, which accounted for the general laddering seen over the whole of the abdomen.

Very careful examination of the alimentary tube was made for any further block, and none was present.

I am indebted to Mr. W. J. Pardoe, of Birmingham, for the illustration.

HERNIA OF THE ILEUM THROUGH A HOLE IN THE TRANSVERSE MESOCOLON

REPORT OF A CASE WITH SYMPTOMS AND RADIOLOGICAL APPEARANCES SIMULATING A MECKEL'S DIVERTICULUM

By RODNEY SMITH, Major, R.A.M.C.

Herniation of the small intestine through a hole in the mesentery of the large or small intestine has been recognized as a possible cause of intestinal obstruction since Treves called attention to the occasional occurrences of such holes in the mesentery of the terminal ileum in 1885. Dolton (1944), in a review of the 76 cases previously recorded, discussed fully the questions of aetiology and symptomatology, and stated "the condition always presents as an acute intestinal obstruction without any specific symptoms or signs. Rarely is there previous suggestive history." He went on to describe the four cases in which previous signs had been suggestive. The case about to be described is remarkable in that the mesenteric hole was in a most unusual site and in that although suggestive signs were certainly present they were strongly suggestive of an entirely false diagnosis.

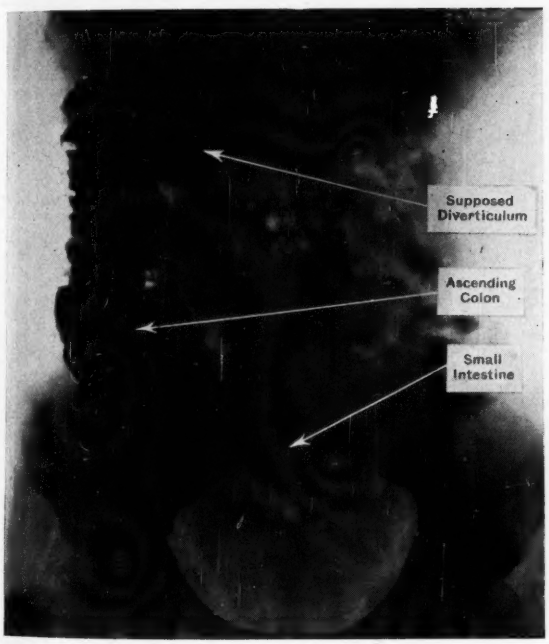

Fig. 219.—Radiograph taken 2½ hours after a barium meal, showing a sausage-shaped segment of small intestine filled with barium and with a blind end pointing to the umblicus.

Fig. 220.—Radiograph at the end of 5 hours. The segment of small gut is still filled, and the large intestine clearly outlined and distinct from it.

CASE REPORT

History.—C. C., a Cypriot of 30, was apparently in fair health until eight months before admission to hospital. Minor attacks of abdominal discomfort before this date were considered to be of very doubtful significance. Eight months before admission he had been admitted to another hospital with an abscess of the umbilicus and had undergone an operation. Inquiry elicited a medical report giving the information that at this hospital a diagnosis of "omphalomesenteric abscess" had been made, that the abscess had been incised and found to communicate with the abdominal cavity thorugh a hole in the linea alba, that this hole had been curetted and not enlarged, and that exploration of the abdomen had not been undertaken. Spontaneous healing had occurred. Since discharge from this hospital the patient had had four attacks of abdominal pain with vomiting. In each attack typical small-gut colic had occurred intermittently over a period of several days and had been accompanied by fairly severe vomiting, marked abdominal distension, anorexia, and general malaise. The patient was normally of irregular bowel habits and often had no bowel action for several days. He did not associate any marked increase or decrease in constipation with the attacks of pain. There had been no bleeding per rectum, no disturbance of micturition, and no other significant symptoms in the history.

On Examination.—No abnormal physical signs were found on general examination, examination of the abdomen, or per rectum, apart from a healed vertical scar, 4 in. long, running through the umbilicus.

The nature of the acute attacks, however, appeared diagnostic of some form of intermittent obstruction of the lower small intestine, while the previous history suggested strongly that the gut might be anchored to the umbilicus by an embryological band with or without a Meckel's diverticulum, a state of affairs commonly associated with obstruction. A radiological examination by following the progress of a barium meal through the gut was performed with the object of determining the

presence or absence of any localized hold-up and with the possibility in mind of visualizing a diverticulum. Nothing abnormal was seen in the stomach or upper part of the small gut, and the first abnormal picture was obtained at 2½ hours (*Fig.* 219). In this picture it will be seen that the barium has filled a sausage-shaped segment of small intestine which appears to have a blind end pointing to the umbilicus. *Fig.* 220 shows the appearance at 5 hours, with the segment of gut still filled and the large gut well outlined and distinct from it. Subsequent examination showed that the segment had emptied completely of barium and could no longer be seen.

Discussing the diagnosis with Major J. F. Grant, R.A.M.C., to whom I am indebted for these unusual radiographs, in spite of the clinical history strongly suggestive of a Meckel's diverticulum and the radiological appearance of just such a blind diverticulum, we were neither of us happy about making a certain diagnosis owing to the extraordinarily high situation in the abdomen. On the other hand, a connexion with the stomach or duodenum was ruled out by the normal appearance of these organs in the early films and by the fact that the segment of gut had not filled until 2½ hours. The large gut was seen to be quite distinct. A fistulous communication with the gall-bladder was also considered, but again the late filling would necessitate the fistula being between the gall-bladder and lower ileum, a most unusual site, and in no picture was barium seen in the biliary tree. It was finally decided that the condition was probably one of a Meckel's diverticulum with the segment of gut bearing it fixed in an abnormally high position in the abdomen by inflammatory adhesions from the previous abscess discharging at the umbilicus.

OPERATION.—The abdomen was opened under general anæsthesia through a long right paramedian incision and the peritoneal cavity was found to be free of any band or adhesion or other evidence of past inflammation. This included the area deep to the umbilicus. There was no Meckel's diverticulum or band. The cause of the attacks of obstruction was, however, quite obvious. A circular hole was present in the transverse mesocolon about 1 in. from the hepatic flexure and through this was herniated a loop of the terminal ileum. The margin of the hole gripped the gut quite firmly without being tight enough to cause obstruction or interference with the vascular supply, but on withdrawing the gut constriction grooves were apparent on the afferent and efferent loops. The defect was found to be circular, about 1 in. across and situated close to the mesenteric border of the colon. It was closed by three interrupted silk sutures and the abdomen closed in layers.

Convalescence was uneventful and the patient has remained free from symptoms.

SUMMARY

Reference is made to recorded cases of intestinal obstruction due to hernia of the gut through holes in the mesentery of the small and large gut, in which almost invariably diagnosis was made at laparotomy for acute intestinal obstruction of unknown aetiology.

A case is described presenting symptoms of intermittent small-gut obstruction over a period of months, but in which details of the history and radiological examination strongly suggested an incorrect diagnosis of a Meckel's diverticulum.

I am indebted to Colonel E. A. P. Brock, late R.A.M.C., for permission to report this case.

REFERENCE

DOLTON, E. G. (1944), *Brit. J. Surg.*, **31**, 275.

AN ENORMOUS EPITHELIOMA ADENOIDES CYSTICUM OF THE SCALP

BY P. GABARRÔ

PLASTIC SURGEON AT AN E.M.S. HOSPITAL

WITH A PATHOLOGICAL REPORT

BY S. L. BAKER

PROFESSOR OF PATHOLOGY AT THE UNIVERSITY OF MANCHESTER

THIS tumour, a benign type of epithelioma, was described as long ago as 1842 by Ancell and since then many other descriptions have appeared. Cohn (1892) called it " multiple sarcoma ", Poncet (1890), Delaye et al. (1931), de Beurmann (1941), Pinkus (1922) have used the term " cylindrome ", while Spiegler (1895) called it perithelioma. Ronchese (1933) thinks it most probable that the tumour originates from the sebaceous glands. Savatard (1922) describes this tumour as of the basal-cell type, originating from the surface epidermis or from the hair follicles. He uses the term " epithelioma adenoides cysticum ", and this term is adopted in the present paper.

These tumours, when of such great size that they cover the head, have been referred to as " turban tumours ". Savatard describes many cases in which the condition is familial ; in the following case there is no familial history.

This case is similar to several described by other authors, but it appears to be the largest " turban tumour " so far recorded. It is interesting because, apart from the unique size of the tumour, it appears to be the first in which radical surgical removal has been successfully performed.

CASE REPORT

HISTORY.—The patient was a married woman, aged 60. Thirty-three years ago she noticed some small tumours in the region of the right eye. These increased in size and spread until the whole forehead and most of the cheeks and scalp were covered by tumours which continued to grow (*Fig.* 221). During the last few months prior to operation the tumours grew more rapidly. Many also appeared on the body from time to time.

ON EXAMINATION.—The growth consisted of a conglomeration of rounded tumours covering the following area : just over the eyebrows, descending on both cheeks in front of the ears, behind both ears, and rising

slightly to the upper part of the occipital region. Inside this area there were very numerous papillomatous outgrowths which overhung, covering both eyes, the nose, and both ears. Many tumours were pedunculated and had a smooth pink surface, generally soft. Several had ulcerations at the peduncular ends which bled easily. A great deal of secretion had accumulated over the area involved, possibly a mixture of sebaceous material, some blood, and discharge from the ulcers. Much of the hair remained. The whole had a very strong, unpleasant smell, like butyric acid, similar to the sebaceous secretion accumulated in cysts.

In the midline of the back there were about thirty smaller tumours, some ulcerated and bleeding, varying

FIG. 221.—Patient's head before operation.

in size from a pea to a lemon. This midline appearance is described by Savatard as characteristic.

There were several smaller tumours spread over the abdomen, but they were much more numerous along the midline (*Fig.* 222) and on the external genitals; small tumours were scattered on both legs.

There was no pain or any other symptom which affected her general condition, except in the social aspect. On account of the size, smell, and ugliness of the tumour she remained in hiding in her home for more than ten years. She was "discovered" by the doctor when her second husband died and was sent to hospital for treatment, which she accepted reluctantly.

THE SURGICAL PROBLEM.—The enormous size of the tumour, the quantity of blood collected in it, together with the age of the patient, presented a very serious surgical problem. Was it advisable to remove the tumour, and if so should it be done by stages or in one operation?

Anatomically the tumour was confined to the soft tissues. A radiograph of the skull did not show any lesion of the bone. The best *plan de clivage* for excision would be between the scalp and the pericranium, and presumably once one edge had been dissected up, the rest could be removed in one piece, leaving the aponeurosis covering the bone. It was clear that the hair could not be preserved. Bearing these considerations in mind, it was decided that the best way of treating the growth would be the boldest—to remove all in one piece, mostly by blunt dissection after the edges had been freed. For a fortnight the scalp was washed daily with a diluted solution of cetavlon in saline. This was necessary to remove all accumulated secretions and concretions.

THE OPERATION.—The operation was performed by the writer on March 25, 1943. Before starting on

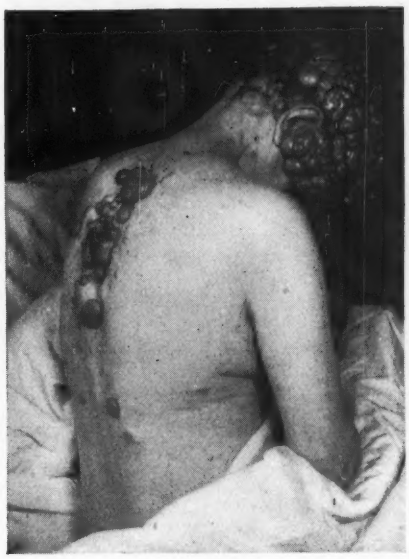

FIG. 222.—Back view, showing string of lumps down the midline.

the scalp, two pieces of thick skin-graft, each 8 in. × 4 in., were cut from the abdomen with the Padgett dermatome.

To avoid as far as possible loss of blood, the main arteries of the scalp were tied by deep sutures placed beyond the limits of the tumour. The dissection of the tumour was commenced at the left temporal side. Provisional scalp hæmostatic forceps were fixed. Even with these precautions the first incision led to a serious sudden loss of blood with a subsequent fall of pressure and apparent collapse of the patient. The blood came more from that collected in the tumour itself than from the network of small arteries. Speed was essential for success and in ten minutes the whole tumour had been

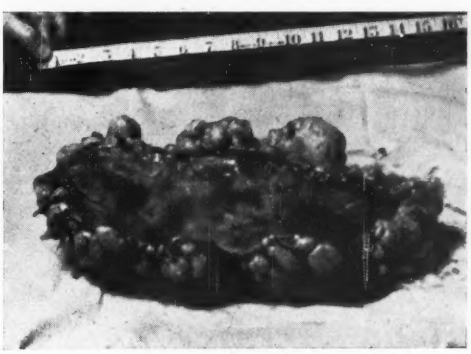

FIG. 223.—Tumour removed in one piece.

excised. The frontal region remained covered by the aponeurosis, but the rest of the skull was left bare. As quickly as possible the grafts were fixed in position at the top of the cranium. The sides were left raw.

Because of the sudden fall of pressure, bleeding stopped. Full advantage was taken of this; all the

hæmostatic forceps were removed, very few ligatures were used, and when the patient's blood-pressure recovered a bandage had already been fixed over the whole scalp applying strong pressure.

The tumour was removed in one piece. Its size was 12 in. × 6 in., weight 4 lb. 2 oz. (*Fig.* 223). It is now preserved in the Museum of the Department of Pathology, University of Manchester.

PROGRESS.—Although the general condition gave much anxiety, the patient was fairly well in a few days and recovered completely.

Eleven days later the dressing was removed. Little more than 50 per cent of the graft had taken. The back

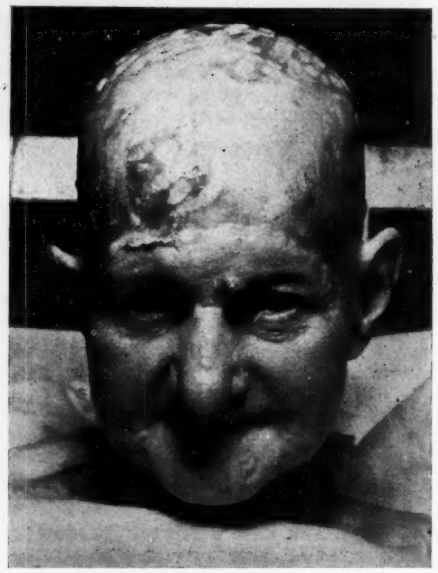

FIG. 224.—The head after operation.

and sides of the scalp remained raw, showing much bare bone. Wet dressings were applied to the bone surface and a fortnight later most of it was covered by granulating tissue.

At a second operation on May 3, 1943, the granulations were shaved down and a continuous sheet of split graft was placed on the raw surface.

Seven days later examination showed the graft to be a complete failure. Two days later a split graft was cut in Gabarró's squares (1943) and placed on the raw area. Four days later the dressing was done: although there was abundant pus most of the squares had taken well. A fortnight later practically all the grafts had spread and the whole area was covered by epithelium.

Two facts deserve some comment:—

1. On account of the bandages several of the tumours had been under some pressure for a few days. The result was that the tumours were depleted (blood? secretions? cells?) and reduced in size; they remained so afterwards. It seems likely, therefore, that pressure might be an aid in the treatment of isolated tumours and might possibly arrest growth.

2. The graft used at the second operation, which was a split graft and placed in *one piece* on the granulations covering the bone, failed completely. The same type of graft, *cut in squares* following the technique described by the writer (1943) and put on the same area two days after the first had failed, took very well and covered the whole area with new epithelium in less than 20 days (*Fig.* 224). On this occasion it was shown once more that the 'island' type of graft was successful where the sheet graft failed.

So far, the other tumours, spread all over the body, have not been treated.

PATHOLOGICAL REPORT

By Professor S. L. BAKER

REPORT ON SECTIONS OF ONE OF THE PEDUNCULATED MASSES.—Epidermis and a thin layer of dermis covers the surface of the tumour tissue, which consists of spherical, ovoid, or irregular masses of basal cells. Each of the main masses is composed of a conglomeration of small cell masses of irregular shape. Most of the cell masses show no structural differentiation; in places, however, there is a branching gland-like arrangement, and the development of hair-follicle structures and small

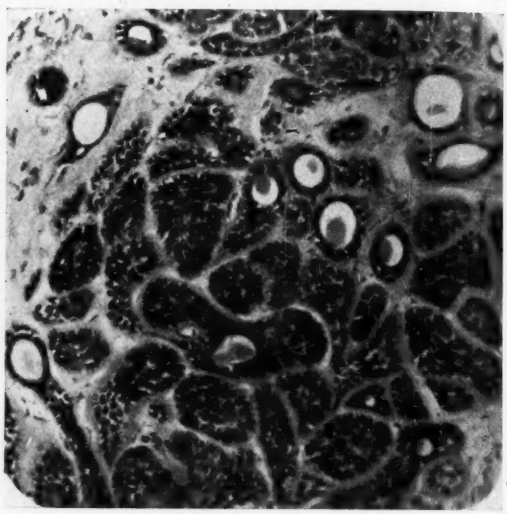

FIG. 225.—Photomicrograph of section through tumour tissue, showing irregular branching cell masses, some of which approach the structure of hair follicles fairly closely, also small cystic spaces. (× 150.)

cystic spaces surrounded by epithelial cells give the picture (*Fig.* 225) characteristic of epithelioma adenoides cysticum (*vide* Savatard, 1938).

SUMMARY

A case of epithelioma adenoides cysticum of the scalp, apparently the largest recorded, is reported. It was completely removed and the result was successful. The distribution of the tumours and the surgical treatment are given in detail. There is a pathological report of sections and some bibliography.

REFERENCES

ANCELL, H. (1842), *Med.-Chir. Trans. Roy. Med. and Chirurg. Soc., London*, **25**, 227.

DE BEURMANN (1941), "Cylindroma", in Neisser and Jacobi's *Ikonographia Dermatologica*, fasc. vii, 263. Berlin and Wien: Urban & Schwarzenberg.

COHN, I. E. (1892), *J. cutan. Dis.*, **10**, 393.

DELAYE, HUGONOT, and LACASSAGNE, J. (1931), *Bull. Soc. franç. Derm. Syph.*, **38**, 1191.

GABARRÓ, P. (1943), *Brit. med. J.*, **1**, 723.

PINKUS, F. (1922), *Arch. Derm. Syph., Wien*, **138**, 342.

PONCET, A. (1890), *Rev. Chir., Paris*, **10**, 244.

RONCHESE, F. (1933), *Amer. J. Cancer*, **17**, Aug.

SAVATARD, L. (1922), *Brit. J. Derm.*, **34**, 381.

— — (1938), *Ibid.*, **50**, 333.

SPIEGLER, E. (1895), *Atti XI Cong. med. intern., Roma*, **5**, 135.

SARCOMA OF THE METATARSAL BONES

A BRIEF REVIEW OF THE LITERATURE, WITH ONE PERSONAL CASE

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SARCOMA of a metatarsal bone is sufficiently rare to warrant the publication of an individual case.

CASE REPORT

HISTORY.—I. P., a male aged 70 years, was admitted to the Cardiff Royal Infirmary on Nov. 16, 1943, with a swelling of the right foot.

In February, 1942, twenty-one months before admission, the patient was working as a labourer, when a heavy iron rail fell on to the dorsum of his right foot, which became swollen and painful. The pain and swelling, however, soon disappeared.

Three months later, while riding in a bus, the patient felt a "dead" pain in the right fore-foot. Ten months later he noticed a swelling for the first time in the region of the base of the right hallux, and the foot was now very painful.

Seven months before admission he had to take a size larger in shoes, and two months later was examined by his private doctor. When the patient was examined at the Out-patient Department of the hospital on Sept. 8, 1943, the swelling had increased in size, and a piece of the shoe had been cut away to allow for it. The foot now was always painful, but the patient could manage to walk, although with a distinct limp. He was X-rayed on this date, and the radiologist, Dr. Wakeman, reported: "Right foot. Except for the head, the first metatarsal is almost completely absorbed. Patchy calcification in the large tumour which replaces the bone. Consistent with osteochondroma. Sarcoma may supervene on this condition". (*Fig.* 226).

FIG. 226.—Radiograph of the foot, showing the tumour involving the first metatarsal.

ON ADMISSION (Nov. 16, 1943).—The patient's only complaint was of a painful swelling of his right foot. His general condition was good.

There was a diffuse swelling of the medial part of the right fore-foot, in the region of the first metatarsal (*Fig.* 227).

The swelling was of a fairly hard consistency, with a smooth surface, an ill-defined edge, gradually tapering away in the region of the shaft of the proximal phalanx of the hallux, and laterally in the region of the shaft of the second metatarsal. The skin over the swelling was smooth and glossy, but was not directly involved by the neoplasm. There was no evidence of metastases.

Another radiograph of the foot was taken on Nov. 11 (10 weeks after the first) and the radiologist reported: "Comparison with the film of Sept. 8 shows increase in size of the tumour from 1¾ in. diameter to 2½ in.

FIG. 227.—Photograph of the foot, showing the swelling in the region of the first metatarsal.

diameter. This strongly suggests a neoplastic condition, i.e., sarcoma."

On the clinical and radiological evidence a diagnosis of sarcoma of the first metatarsal bone was made.

FIG. 228.—Photograph of a sagittally-cut section through the first metatarsal bone showing the neoplasm.

TREATMENT.—On Nov. 25, under general anæsthesia, a below-knee amputation at the site of election was performed (I. J. T.).

Convalescence was uneventful, and there was no undue delay in the healing of the stump. He was

transferred to a convalescent home on the twelfth day after operation, from where he was discharged on Feb. 3, 1944. At this time the stump was well healed and painless, and there were no signs of metastases.

FOLLOW-UP.—The patient was re-examined at intervals, and over 14 months after operation there was no sign of a recurrence and the general condition of the patient was excellent.

PATHOLOGY.—

1. *Macroscopical Appearance* (*Fig.* 228).—A sagittally cut section of the right foot through the first metatarsal shows a nearly circular neoplasm, approximately 3 in. (7·5 cm.) in diameter, which has destroyed the shaft of the bone, leaving only its base and a small part of the head, with its articular cartilage.

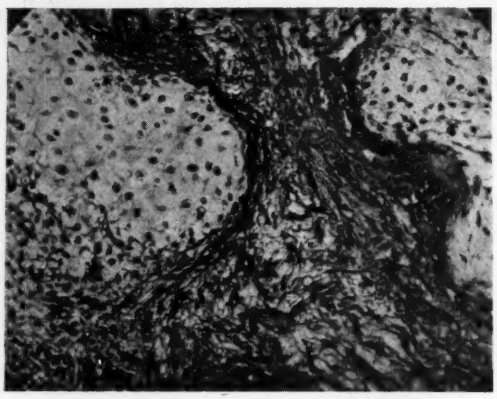

FIG. 229.—Microphotograph of the neoplasm, showing the typical structure of chondrosarcoma. (× 100.)

At no point is there any actual involvement of the skin, although it is in due apposition to the growth on its dorsal surface. The articular surfaces of both ends of the bone are intact and not invaded by the neoplasm.

The sectioned specimen reveals an osteochondrosarcoma with its centre red, fleshy, and vascular, showing areas of hæmorrhage and necrosis. In the periphery of the tumour there are islands of cartilaginous tissue of a myxomatous appearance, separated by thin connective-tissue septa. There is also a small amount of new-bone formation.

2. *Microscopical Appearance* (*Fig.* 229).—Report by Dr. J. Gough: "Sections were taken from several parts of the growth and all showed the characteristic structure of chondrosarcoma. The tissue was intersected by bands of hyaline fibrous tissue in which there were no neoplastic cells. The tumour tissue proper was of varying cellularity, but even in the most cellular parts its cartilaginous nature could be recognized. There was considerable irregularity in the size and arrangement of the cells. There were areas of myxomatous degeneration and small areas showing bone formation."

DISCUSSION

The literature on the subject is scanty, but a review of it shows that only comparatively rarely do malignant tumours of any kind originate in the bones of the hands and feet. This statement can easily be verified by considering the statistics of any large hospital.

In 1933 Dodd reported a case of amputation of a foot where a march fracture had been wrongly diagnosed as sarcoma of a metatarsal bone.

Watson-Jones (1943), in the recent edition of his book, mentions Dodd's paper when discussing march fracture of the metatarsals, and writes: "If sarcoma of the metatarsals was not so rare as to be almost unknown, the periosteal elevation and ossification and the absence of a history of injury might be confusing."

Mercer (1936), in his section on osteogenic sarcoma, mentions that: "For some reason the short long bones appear to be immune". Illingworth and Dick (1941) consider that: "Sarcoma of the smaller bones of the hands and feet is exceptional", and Kahn also pointed out that malignant tumours of the bones of the hands and feet are extremely rare.

Schreiner and Wehr (1933) surveyed a series of 10,459 cases of malignant disease over a nineteen-year period, and could find only 37 involving the foot and only 4 of these were bone sarcomas. Of 1740 bone tumours at the Johns Hopkins Hospital, Moore (1931) found 46 benign and malignant tumours of the foot, but the number of tumours occurring in the metatarsal bones was not mentioned.

The most complete paper dealing with the subject is that of Coley and Higinbotham (1939), and in a review of 1211 bone tumours at the Memorial Hospital and the Hospital for Ruptured and Crippled, New York, they found only 47 instances of involvement of the bones of the hands and feet. Twenty of these involved the bones of the hands, and 27 the bones of the foot. They note that considering there are 206 bones in the entire skeleton, 106 of which are in the hands and feet, the statistics show the disproportion of tumours in these bones.

From the American and foreign literature they were able to collect a total of 609 cases of tumours involving the bones of the hands and feet, but 205 of these were subcalcaneal exostoses. They found a remarkable sparsity of all other types of primary bone tumours of the hands and feet, but the proportionate number roughly corresponded to their own series.

The malignant tumours of the metatarsal bones in their own series totalled 10, made up as follows:—

Osteogenic sarcoma	5
Giant-cell tumour	2
Ewing's endothelioma	2
Angiosarcoma	1

From the literature they collected a total of 38 cases:—

Osteogenic sarcoma	3
Giant-cell tumour	9
Cyst	5
Exostosis	3
Ewing's endothelioma	6
Chondroma	7
Metastatic	2

There were also 3 cases described in the literature as sarcoma of the metatarsal bones without further differentiation as to type.

In all, therefore, there were 8 proven cases of osteogenic sarcoma, 8 cases of Ewing's endothelioma, 1 case of angiosarcoma, and 3 other unclassified sarcomatous tumours.

It is difficult to obtain full accounts of all these cases, but Coley and Higinbotham have followed their 10 cases, details of which are given in *Table I.*

DIAGNOSIS

The diagnosis may be one of extreme difficulty, and only after careful investigation should a sarcoma of a metatarsal bone be diagnosed.

Sometimes the patient gives a history of trauma, but the true value of this in the aetiology of the condition is open to question. Lichtenstein and Jaffe (1943), from a study of 15 chondrosarcomas of bone and a review of the cytology of benign growths, from which chondrosarcoma so often evolves, consider that trauma does not seem to be a factor in the initiation of chondrosarcoma or in malignant transformation of enchondroma and osteochondroma. (In this series, however, the metatarsal bones were not affected).

Clinically, the history usually given is of pain in the affected region, followed shortly after by swelling and disability. There is a hard palpable swelling which increases in size with relative rapidity.

Radiographic examination shows characteristic irregular bone destruction, and possibly laying down of new bone, often with the typical 'sun-ray' appearance.

Coley, Sharp, and Ellis (1931), in order to verify the clinical and radiographic findings, recommended aspiration biopsy as a valuable aid in the accurate diagnosis of the tumour.

Table I.—COLEY AND HIGINBOTHAM'S TEN CASES

No.	Name	Sex	Age	Bone	Diagnosis	Admitted	Treatment	Follow-up	Remarks
1	D. D.	M.	33	R.	Osteogenic	25/8/29	Amputation	11/5/32	Well
2	M. R.	F.	34	L.2.	Osteogenic	19/5/33	Amputation	16/5/35	Died; pulmonary metastases
3	J. S.	M.	65	R.5	Osteogenic	8/5/31	X rays, amputation	7/11/37	Well
4	V. V.	M.	23	R.1	Osteogenic	23/7/24	Excision, X rays	7/1/28	Final, not traced further
5	L. W.	F.	34	R.4	Osteogenic	3/3/30	X rays, radium, curettage, amputation	14/2/38	Well
6	H. N.	M.	32	R.1	Giant-cell	22/7/26	Curettage	15/11/37	Well
7	H. S.	F.	17	L.4	Giant-cell	30/8/37	Curettage, (recurred) excision	13/4/38	Well
8	C. F.	M.	33	R.3	Endothelioma	17/10/24	Excision, radium	26/9/26	Died; multiple metastases
9	E. K.	F.	23	L.1	Endothelioma	25/10/24	Excision, radium, X rays	30/4/25	Died
10	R. V.	M.	33	R.3	Angiosarcoma	26/4/25	Amputation	5/5/25	Died; multiple metastases

PATHOLOGY

Lichtenstein and Jaffe (1943) have stressed the importance of differentiating chondrosarcoma from osteogenic sarcoma. The former develops from fully-fledged cartilage and the latter from more primitive tissue, the bone-forming mesenchyme. Some chondrosarcomas show large areas in which the intercellular matrix of the tumour cartilage has become heavily calcified or ossified, and in some osteogenic sarcomas cartilage in considerable amounts may be formed in the course of osteogenesis from the primitive mesenchyme. However, chondrosarcoma never shows tumorous osteoid tissue and bone evolving from a sarcomatous stroma directly, such as one always sees somewhere in osteogenic sarcoma, no matter how much cartilage it contains.

They note that a central chondrosarcoma begins in the interior of a bone and a peripheral one in the cartilaginous cap of an osteochondroma. It is in the latter and those central ones which have clearly evolved from benign enchondroma that one finds, at least in the earlier stages of evolution of the lesion, heavy calcification or ossification of large parts of the intercellular matrix of the tumour cartilage. In other chondrosarcomas the relevant neoplastic tissue is likely to consist, in the main, of compacted islands of cartilage with hyaline matrix, though, if the chondrosarcoma is bulky, areas in which the cartilage is softer and myxomatous and perhaps even necrotic may also be found.

From a study of their material Lichtenstein and Jaffe concluded that the histological picture of a particular lesion (irrespective of its gross appearance) does not have to be crudely and obviously sarcomatous to indicate chondrosarcoma, and that it is a mistake to suppose that to make a diagnosis of chondrosarcoma on a histological basis alone is often difficult if not impossible. Even in the early stages of a chondrosarcoma, they found, at least in scattered fields and if adequate material were examined, subtle but tell-tale evidence of cytological atypism of the cartilage cells which will betray the malignant character of the lesion.

According to their criteria a cartilage tumour should no longer be regarded as benign if, when viable and not heavily calcified areas are examined, it shows even in scattered fields: (1) Many cells with plump nuclei; (2) More than an occasional cell with two such nuclei; (3) Any giant cartilage cells with large single or multiple nuclei or with clumps of chromatin.

If these criteria are observed they believe that the prevalent tendency to "underdiagnosis" of chondrosarcoma in an early stage of malignancy can be overcome.

TREATMENT

The treatment naturally depends on the type of sarcoma, the degree of malignancy, and the stage at which the condition is seen.

Chondrosarcoma tends to appear at a later age than osteogenic sarcoma, runs a much slower course,

and, especially, if given radical surgical treatment, at an early stage has a much better prognosis, since the tumour has usually not metatasized at the time of the initial surgical intervention. The fibro-sarcomatous type of tumour offers an even more hopeful prognosis.

As the sarcoma of the metatarsal bone is a tumour which tends to metastasize late, the best form of treatment is primary amputation. This is performed either below the knee with a 5½-in. stump or through the middle of the thigh. Local excisions should not be advised.

Post-operative deep X-ray therapy should also be given in most cases, although this has not been done in the author's personal case. The only series of cases carefully followed-up is that of Coley and Higinbotham shown in the table. Five of their patients were alive and well (3 for more than 5 years); 4 died of pulmonary metastases from one to three years after admission; and 1 died following a prostatectomy nine years after amputation of the foot for osteogenic sarcoma. The other 2 were lost to follow-up, but one was undoubtedly dead, as he had pulmonary metastases six months after treatment.

From what has been said, it would appear that sarcoma of a metatarsal bone offers a more favourable prognosis than does the same condition in other bones.

SUMMARY

A personal case of sarcoma of the first metatarsal bone is described. Treatment was by amputation below the knee, leaving a 5½-in. stump. The patient is well over 14 months later, with no sign of recurrence.

A review of the literature shows sarcoma of a metatarsal bone to be a comparatively rare condition. The 5-year cure rate is roughly 33 per cent, and it appears that sarcoma of a metatarsal bone offers a more favourable prognosis than does the same condition in other bones.

I am greatly indebted to Mr. Ioan-Jones, under whose care the patient was admitted, for allowing me to operate on this case and for permission to publish this report. My thanks are also due to Dr. Jethro Gough, for the histological report; to Dr. Wakeman for the radiological reports; to Professor J. D. Duguid; and to Dr. L. P. Thomas for the photographs.

REFERENCES

COLEY, B. L., and HIGINBOTHAM, N. L. (1939), *Surgery*, **5**, 112.
— — and SHARP, G. S. (1931), *Amer. J. Surg.*, **3**, 215.
DODD, H. (1933), *Brit. J. Surg.*, **21**, 131.
ILLINGWORTH, C. F. W., and DICK, B. M. (1941), *Textbook of Surgical Pathology*, **4**, 166.
LICHTENSTEIN, L., and JAFFE, H. L. (1943), *Amer. J. Path.*, **19**, 553.
MERCER, W. (1936), *Orthopædic Surgery*, 2nd ed., 208.
MOORE, J. R. (1931), *Radiology*, **16**, 232.
SCHREINER and WEHR (1933), *Ibid.*, **21**, 513.
WATSON-JONES, R. (1943), *Fractures and Joint Injuries*, 3rd ed., 259.

A CASE OF COMMON ILIAC ANEURYSM IN A CHILD

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ANEURYSM in adults is becoming less frequent, but it has always been a very uncommon disorder in childhood, and therefore such a case with the result of radical surgery is recorded.

CASE REPORT

HISTORY.—The patient, a female aged 10 years, was one of six children, the last-born of whom died in early infancy. The child had enteritis, measles, and chicken-pox in early childhood, but otherwise had been well. Her parents have good health and there have been no miscarriages, stillbirths, or congenital abnormalities in the family. She could recollect having been pushed down some steps and having had two other minor accidents in play, but no severe abdominal injury had ever been sustained. She had complained of abdominal pain on and off from January, 1944.

On March 18, 1944, she was admitted to the Abertillery and District Hospital with a pain in the right side of the abdomen and generally feeling out of sorts, but no vomiting. On examination there she had a temperature of 100° and tenderness in the right iliac fossa, with rigidity of the lower abdominal muscles and a palpable mass. A diagnosis of acute appendicitis with probable matting of the omentum round the appendix was made and an operation performed by Mr. R. W. Scanlon, F.R.C.S. Under anæsthesia the mass appeared to be more central in position and so a right paramedian incision was resorted to. A small quantity of free peritoneal fluid was found, the appendix appeared normal and was not removed. The tumour was retroperitoneal, the size of an orange, and lying over the 4th and 5th lumbar vertebræ—circumscribed and rounded, with an expansile impulse which ceased on pressure of the abdominal aorta above the swelling. It was considered that the expansile pulsation was caused by the tumour lying over the bifurcation of the aorta and that the iliac arteries communicated the apparently expansile pulsation. A tentative diagnosis of retroperitoneal abscess or dermoid was made and the abdomen closed pending further investigation.

Subsequent radiography showed no erosion of the lumbar vertebræ. There was some daily temperature fluctuation between 99° and 101·5° F. for three weeks, but it gradually settled to normal in the fourth week. The patient made an excellent recovery, got up and about, but the mass remained unaltered.

ON ADMISSION.—The patient was admitted to St. James's Hospital on April 19. She was an intelligent rather spare child, weighing 3 st. 12 lb., of normal stature for her ten years. Clinical examination of the cardio-vascular, respiratory, and nervous systems revealed no abnormality. The blood-pressure in the arms was 104/60 and in the legs ?/60. The retinal arteries were of normal appearance. Inspection of the abdomen showed a well-healed right paramedian scar and a visible swelling with its centre 3 cm. below and to the right of the umbilicus. On palpation there was now no rigidity or guarding and a mass was felt extending below

to 2 cm. above the right inguinal ligament, and across to the left of the midline and above to just above the umbilicus. It was round in shape and had well-marked expansile pulsation in all directions. The femoral pulses were equal. The mass ceased to pulsate and became smaller on pressure on the aorta. A straight radiograph showed a rounded shadow over and to the right of the 4th and 5th lumbar and 1st sacral vertebræ.

Blood examination showed the Kahn test negative and the count was as follows :—

R.B.C., 5,300,000 per c.mm.
Hæmoglobin, 84 per cent. C.I., 0·80.
W.B.C., 12,400 per c.mm.
Differential W.B.C. :—

Polymorphs, Neutrophils	50	per cent
Eosinophils	1	,,
Lymphocytes	41	,,
Monocytes	8	,,

Stained film. No abnormality seen.

She was apyrexial on admission and remained so.

It was decided to give the child a few weeks' rest in bed in view of the previous pyrexia in case there was any periarterial suppuration, and to increase the collateral circulation.

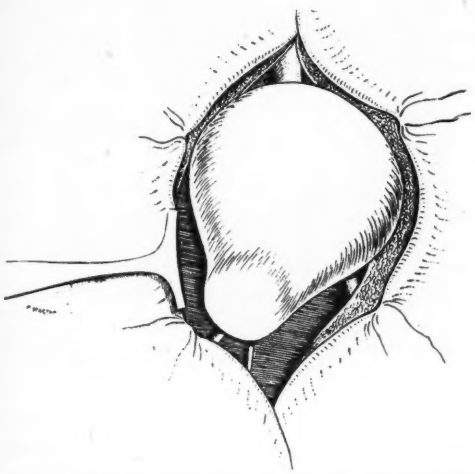

FIG. 230.—Reconstructed diagram of the appearance of the aneurysm at operation.

On May 22 the child was re-examined and to our alarm the mass was bigger by a fresh asymmetrical bulge which gave the impression of being subcutaneous, the palpable diameters now being 9 cm. by 7 cm., and it was decided to postpone the operation no longer.

AT OPERATION.—On May 23, under avertin, gas, oxygen, and ether anæsthesia in the Trendelenburg position, a right paramedian incision was re-made and multiple small intestinal adhesions were divided. A large mass, now aneurysmal without any doubt, was found, and to expose it adequately the incision had to be prolonged from pubis to high in the epigastrium. Above, the aorta could be felt, but the right internal and external iliac arteries were obscured by its bulk. The aneurysm had a bulge on its otherwise oval contour—the recent sudden enlargement (*Fig.* 230). No visceral abnormality was present.

The peritoneum over the aneurysm was divided. It was some 11 cm. by 7 cm. in diameter and the ureter was seen coursing along its outer side. By dissection at the uppermost limit the aorta was exposed. One now gained the impression that the aorta was entering its upper part, and this was gently freed up and a silk ligature placed round it in case of accident. Downward traction on the upper pole of the aneurysm failed to show its exact origin—it was too bulky to get an adequate view. Consequently the aorta above, the left common iliac and the right external iliac arteries were compressed after gently compressing the aneurysm. When pulsation was stopped the aneurysm was rapidly incised, its clot extracted and the incision and aneurysm clamped with a very strong sponge forceps. The aneurysm was thereby made much smaller, about one-third its previous size, and dissection above now showed that although the aneurysmal dilatation involved the right common iliac artery at its origin, the lowest aorta and left common iliac artery appeared normal. Two firm silk ligatures were placed around the right common iliac artery at its origin from the aorta, care being taken not to obstruct the left common iliac artery although it was of necessity distorted slightly. It was now comparatively easy to ligate the external iliac artery at its exit from the aneurysm and the internal iliac artery was also tied at its separate point of exit from the sac, 2 cm. from the external artery. The aneurysm was now freely reopened and found to have a very small inflow of blood. Most of the wall was excised, but the posterior wall was left in situ and obliterated completely by a series of fine interrupted silk stitches. The common iliac vein was not ligatured. A right lumbar sympathectomy was now started and the fourth right lumbar ganglion was just removed when the anæsthetist suggested that signs of surgical shock were causing disquiet and so after quickly resuturing the posterior peritoneum (which had been opened almost as high as the duodenum) the abdomen was closed.

A blood transfusion had been started during the operation and was continued post-operatively. Immediately after the operation the pulse was rapid and of low tension. The right leg was blanched from the knee downwards.

On return to the ward the leg as high as the knee was kept cool by wrapping it in two layers of blanket and placing outside these four ice bags, but the rest of the body was kept warm. A transfusion of plasma later replaced the blood until the general condition gave no more cause for alarm, and heparin was added to the intravenous drip. Gentle massage was given to the leg. The foot became rather cyanosed a few hours after the operation.

PROGRESS.—On May 25 the sole and fifth toe appeared of good colour but the dorsum and first, second, third, and fourth toes were blotchily cyanosed. At this stage she had an attack of vomiting which subsided after continuous gastric aspiration by an indwelling transnasal œsophageal tube and restricting oral fluids for twenty-four hours.

On May 26 her vomiting had ceased. Her general condition was better and the fourth and fifth toes were pink.

On May 28 the condition shown in *Fig.* 231 was present.

On June 2 the tip of the first toe was blue with an area of doubtful viability.

On June 10 tiny necrotic patches were present at the tips of the first, second, third, and fourth toes. Now well and getting up.

On June 17 the patient was discharged with instructions to keep toes dry and powdered. The abdominal wound was soundly healed.

January, 1945 : The child is now in excellent general health, the foot appears normal apart from fine scars on the tips of the first, second, and third toes, and no marked difference in colour or temperature can be discovered between the two legs.

Dr. B. Barling has kindly examined the child and reports that there is now no evidence clinically, radiologically, or electrocardiographically of any congenital abnormality in the cardiovascular system, of congenital syphilis, or of recent or past rheumatism.

MICROSCOPY OF THE WALL OF THE ANEURYSM (Dr. A. B. Bratton).—The histological report on the excised part of the aneurysmal wall was as follows :—

"The specimen consisted of two irregularly oblong portions, the larger 1 cm. long by 0·5 cm. deep, of tough, brownish-grey tissue showing no definite structure.

"Microscopically they are seen to be portions of arterial wall in which great fibrosis has rendered the coats not easily distinguishable. There is great hyaline fibrosis of the intima, which is in places lined with

FIG. 231.—Appearance of foot on May 28, 1944, five days after operation.

structureless adherent clot. In the smaller portion there is between the intima and media a cleft, the walls of which show chronic inflammatory infiltration, especially on the medial side.

"There is great fibrosis of the media, little elastic remaining; in one place in the larger portion it is narrowed in a tapering manner almost to nothing. There is a slight excess of vascularization in the media.

"The adventitia is fibrotic and greatly thickened. In it is an area of chronic inflammatory infiltration and a few nodules of foreign-body giant-celled granulation tissue; a giant cell in one of these includes an elongated, unstained, refractile foreign body and others show clefts.

"There is no evidence of activity of the process that produced this result. The presence of the foreign body is somewhat suggestive of a traumatic origin."

COMMENT

Aneurysm in children is an uncommon disease and most of the recorded cases have been in the first part of the aorta, and most have ruptured spontaneously. Pilcher, in 1937, reported 4 cases of aneurysm of the thoracic aorta and cited Calvin and Nichamin's series of 44 thoracic aortic aneurysms.

Aneurysm of the abdominal aorta appears to be much rarer in childhood, though W. E. Tanner, in 1926, described a case in a girl aged 15 involving the lower end of the abdominal aorta, which ruptured with fatal effects while the child was awaiting operation as a probable appendix with a palpable mass.

I can find no reference to iliac aneurysm in childhood, but in 1926 N. C. Lake described a saccular aneurysm of the common femoral artery which he successfully excised in a child aged 10. Bronson and Sutherland recall two cases of ruptured aortic aneurysm in childhood described in 1834 and 1857 by Miquel and Armitage respectively.

The aetiology of the condition is often difficult to elucidate with certainty. Bronson and Sutherland in 1918 suggested the following classification of aneurysm in childhood: (1) Arteriosclerotic; (2) Traumatic; (3) Embolic or septic; (4) False, due to erosion from without; (5) Congenital anomalies.

Of the 48 thoracic aneurysms recapitulated by Pilcher, 24 were associated with endocarditis or rheumatic fever, 2 with syphilis, 5 were the result of external erosion by suppurating or caseous lymph-nodes, 5 were associated with congenital anomalies of the aorta, and 2 were doubtfully the result of trauma.

W. E. Tanner's case of abdominal aneurysm mentioned above occurred in the third week of scarlet fever complicated by nephritis and albuminuria and was a mycotic aneurysm.

N. C. Lake's case of femoral aneurysm had been preceded eighteen months previously by a pyrexial attack diagnosed as endocarditis, and the child had congenital heart disease. Lake considered it to be a mycotic embolic aneurysm.

In the case I have recorded the causation is uncertain. Trauma is highly unlikely in such a deep-seated vessel with so trivial a history. There is no evidence of degenerative vascular disease, syphilis, or rheumatism. Endocarditis or mycotic embolism can reasonably be excluded and apart from the preceding pyrexia which may have been due to the formation of clots in the aneurysm or peri-arterial suppuration there is no evidence in their favour. No local congenital abnormality was demonstrable at the operation. One is left with the possibilities of:—

1. Erosion or infection of the arterial wall from without resulting from an iliac lymphadenitis (but there is no definite evidence of this or of an infective lesion of the area drained by this gland).

2. A possible congenital defect of the media cannot be excluded (but in the absence of other aneurysms it seems unlikely).

3. Trauma (of which there is only the most trivial history, but which is to some extent supported by the histological findings).

BIBLIOGRAPHY

BRONSON, E., and SUTHERLAND, G. A. (1918), *Brit. J. Child. Dis.*, **15**, 241.
LAKE, N. C. (1926–7), *Trans. med. Soc. Lond.*, **50**, 112.
PILCHER, J. F. (1937), *Tex. St. J. Med.*, **33**, 373.
TANNER, W. E. (1926–7), *Trans. med. Soc. Lond.*, **50**, 112.

A LARGE TESTICULAR TUMOUR

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In view of the fact that malignant disease of the testis rarely leads to a large tumour, the following case would seem to be worth putting on record.

CASE REPORT

The patient was a man of 69, without friends or relations and not very intelligent, so that it was difficult to get a history from him. He had a

Fig. 232.—Photograph showing the enormous scrotum.

scrotal swelling which had probably been present for at least 2 years, because for the last 12 months he had been in a Public Assistance Institution.

His condition when first seen is shown in the photograph (*Fig.* 233), the scrotum reaching to the knees. Walking was impossible, and he was in great discomfort, so that operation was decided on.

At operation, the only difficulty was found to be in the network of large veins in the skin of the scrotum, many of which were the size of a lead pencil. The growth was infiltrating the skin in the lower part, but the upper part of the tunica vaginalis was patent and contained 3½ pints of fluid.

After satisfactory progress for 4 days, he suddenly collapsed and died. A post-mortem examination was held and no glands or secondaries were present.

The Specimen.—I am indebted to Dr. Gleave, Pathologist to the Royal South Hants and Southampton Hospital for his report: "This huge tumour (weight 11 lb. 4 oz.) (*Fig.* 233) shows on section soft brain-like new growth with a large amount of hæmorrhage and necrosis which obscures the histology (*Fig.* 234). The tumour is made up of rounded or polygonal cells with a densely staining round nucleus. Mitotic figures are not seen and thest roma is very scanty. This is no doubt a type of embryonal carcinoma of the testis, though the typical glycogen-containing cells are not seen".

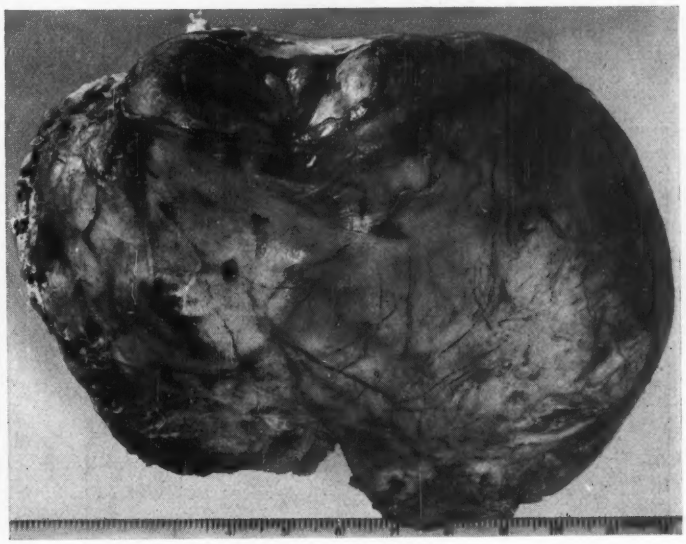

Fig. 233.—The tumour.

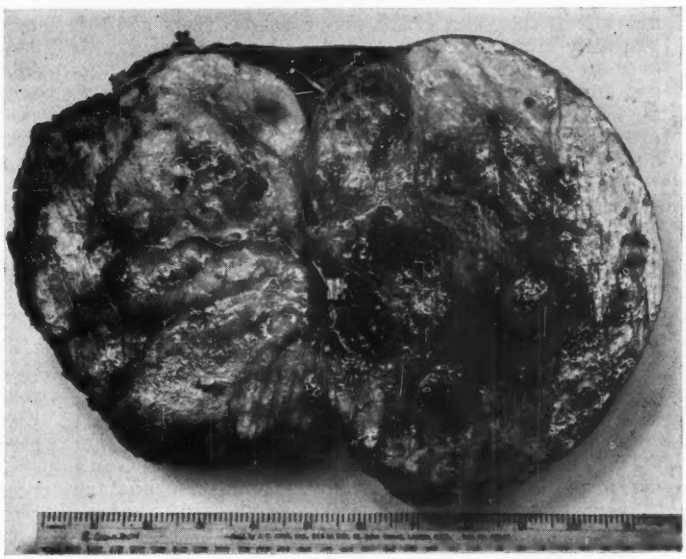

Fig. 234.—Section through the tumour, showing hæmorrhage and necrosis.

The specimen is now in the Museum of the Royal College of Surgeons.

A FIBROLIPOMA OF THE CHEEK

By CHARLES NOON, Norwich

A FIBROLIPOMA of the cheek which can be protruded through the mouth by the patient at will is rare, and would seem worth reporting.

CASE REPORT

I saw this patient in consultation with Dr. Healey in December, 1942. The patient had been an inmate of a mental hospital for many years. A tumour began to develop in the right cheek about twelve years ago; it gradually increased in size until it extended downwards over the lower jaw and hung down from the cheek. Its size and position is well shown in the photograph (*Fig.* 235). It was well defined, soft in consistency, had definite margins, and was freely moveable. It gave the patient no inconvenience. Without the slightest difficulty he could cause the tumour to prolapse through the mouth and with equal ease and a slight sucking effort again retract it into the cheek. The position as it protrudes through the mouth is shown in *Fig.* 236. As the tumour caused no inconvenience, the patient was most reluctant to consider any operation for its removal. No operation was therefore done during life. The tumour was removed post mortem. *Fig.* 237 shows the fibrolipoma after removal.

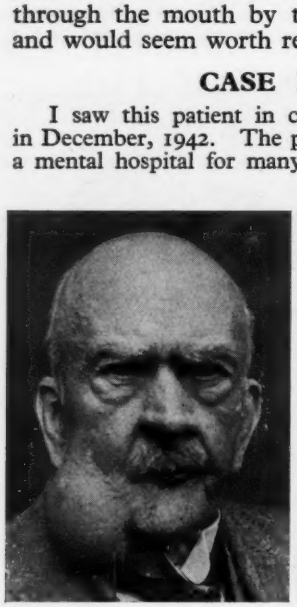

FIG. 235.—Fibrolipoma of cheek.

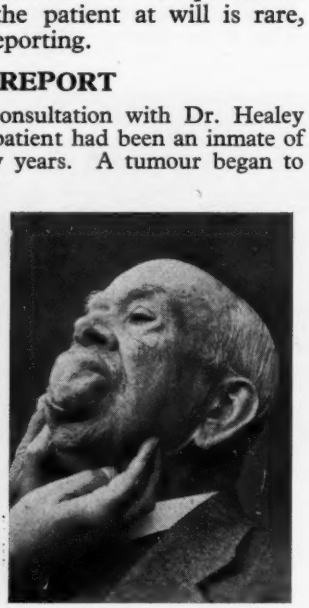

FIG. 236.—Fibrolipoma protruding through the mouth.

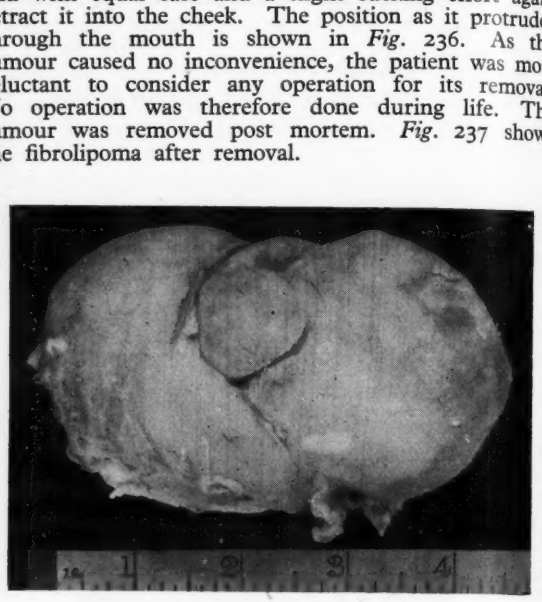

FIG. 237.—Photograph of the fibrolipoma after removal.

HISTOLOGICAL REPORT.—Section of the tumour shows adipose tissue with a large admixture of fibrous tissue. No capsule formation is present in the material examined. There is a thin covering of squamous epithelium on one surface, with an underlying chronic inflammatory reaction. The epithelial covering is replaced in part by granulation tissue. The histological features are those of a fibrolipoma.

REVIEWS AND NOTICES OF BOOKS

An Index of Differential Diagnosis of Main Symptoms. By various writers. Edited by HERBERT FRENCH, C.V.O., C.B.E., M.A., M.D. Oxon., F.R.C.P., Consulting Physician, Guy's Hospital; late Physician, H.M. Household; assisted by ARTHUR H. DOUTHWAITE, M.D., F.R.C.P., Physician, Guy's Hospital; Honorary Physician, All Saints' Hospital for Genito-urinary Diseases. Sixth edition. 9¾ × 6⅝ in. Pp. 1128 + viii, with 798 illustrations, of which 231 are coloured. 1945. Bristol: John Wright & Sons Ltd. 84s.

THE new sixth edition of Herbert French's great work has been thoroughly revised and brought up to date. It is a large volume, consisting of over 1100 pages, profusely illustrated and beautifully printed on good paper, which is a triumph for medical publication in wartime.

Dr. French has taken Dr. Douthwaite as his collaborator in this edition, and one is interested to read that Dr. Douthwaite will be responsible for future editions. This book has become the mainstay, not only of general practitioners, physicians, and surgeons the world over, but has become a book of reference for the whole medical profession who want to look up any special disease or condition.

The coloured illustrations, which are numerous, have always been a feature of this book and they are a great help in the elucidation of the text.

We fail to see how a better book could possibly have been written on the Differential Diagnosis of Main Symptoms. The Index is most comprehensive and occupies no less than 183 pages. This book will continue to take its place among the really important medical books.

Plaster of Paris Technic. By EDWIN O. GECKELER, M.D., Associate Professor of Orthopædic Surgery, and Chief of the Fracture Service, Hahnemann Medical College and Hospital, Philadelphia. 9 × 6 in. Pp. 220 + x, with 208 illustrations. 1944. Baltimore: The Williams & Wilkins Co. (London: Baillière, Tindall & Cox.) 16s. 6d. net.

THIS book should find a useful place in the libraries of the orthopædic and fracture departments of hospitals both large and small.

The early chapters provide adequate and well set-out information on the making of plaster bandages, the technique of bandaging, and the instruments and appliances generally used in the plaster theatre. These chapters would be of especial benefit to the Orthopædic Sister or Senior Nurse. The need for padding and bivalving post-operative plaster casts cannot be too strongly emphasized, but there is much repetition of this and other statements in the text and legends of the later chapters.

Although in his preface the author explains that "orthopædic technic and reduction of fracture have been intentionally avoided", it is difficult not to criticize the rationale of some types of plasters illustrated. A shoulder spica for an acromioclavicular dislocation; an above-elbow plaster for a Colles's fracture; and a plaster extending from below the elbow to the terminal phalanx in the treatment of a fractured metacarpal—all these are examples of over-elaborate immobilization of a limb.

The book is well produced and the illustrations clearly show the high standard of plaster technique achieved by the author in his own clinics.

Surgery of the Hand. By STERLING BUNNELL, M.D. 10 × 7 in. Pp. 734 + xviii, with 597 illustrations. 1945. Philadelphia and London: J. B. Lippincott Co. 72s. net.

THIS large monograph is comprehensive and lavishly and beautifully illustrated. At no time in the history of man has the human hand been subjected to such a variety of trauma, for in this mechanical age the various traumatic lesions to which the hand is liable are legion and the second world war has greatly increased the number of mutilated hands which require reconstructive and plastic surgery.

Malformation, injury, and infection swell the ever-coming stream of crippled hands needing repair. The author has tackled all these main problems in a thorough and practical manner and has demonstrated his technique of dealing with the restoration of cut tendons in an excellent fashion.

The damaged hand is often a complex problem as far as treatment is concerned, for it necessitates the correlation of various specialities—orthopædic, plastic, and neurological surgery. No doubt this will soon be covered by the industrial surgeon of the future.

Dr. Bunnell is to be congratulated on having presented the profession with such a useful book.

A Text-book of Surgical Pathology. By CHARLES F. W. ILLINGWORTH, M.D., Ch.M., F.R.C.S. (Ed.), Regius Professor of Surgery, University of Glasgow; and BRUCE M. DICK, M.B., F.R.C.S. (Ed.), Surgeon for Diseases of the Chest, E.M.S., West of Scotland. Fifth edition. 9⅛ × 6 in. Pp. 728 + viii, with 306 illustrations. 1945. London: J. & A. Churchill Ltd. 42s.

THIS text-book of surgical pathology was born to popularity amongst students and practitioners alike, for it covered the subject in a concise and masterly fashion. Small wonder then that the fifth edition appears a little over ten years after the first edition; and, the fourth edition was reprinted.

This new edition has been brought thoroughly up to date and new illustrations have been added.

A number of new subjects have been added, chief of which are the crush syndrome, sarcoidosis of Boeck, solitary plasmacytoma of bone, adenolymphoma of the salivary glands, argentaffine tumours of the intestine, and interstitial-cell tumour of the testis.

An excellent text-book.

Surgical Disorders of the Chest. Diagnosis and Treatment. By J. K. DONALDSON, B.S., M.D., F.A.C.S., Major, M.C., A.V.S., Associate Professor of Surgery and in Charge of Thoracic Surgery, University of Arkansas School of Medicine; etc. 9 × 5¾ in. Pp. 364, with 127 illustrations. 1945. London: Henry Kimpton. 33s. net.

COMPREHENSIVE monographs on thoracic surgery are comparative rarities, and it is in consequence gratifying that this work of Major Donaldson's is now available. The book is written primarily for the general practitioner and general surgeon, so that there can be little criticism from the specialist in this branch who might wish to join issue on a good many points of detail. The only real objection that can be offered to this otherwise admirable book is the fact that the main principles of thoracic surgery tend to become lost in a mass of detail which might in part have been omitted.

Some chapters read very well and clarify difficult subjects, and the section on lung abscess, for example, is most satisfactory. Injuries, œsophageal lesions, and carcinoma of the lung receive careful consideration, but the treatment of empyema—a vitally important matter—is dismissed briefly without much indication as to the control of healing or, indeed, as to the whole course of action.

The number of suggested modifications for thoracoplasty suggest that the standard paravertebral operation with apical mobilization as routinely practised in this country has not found full acceptance in the author's hands and the same applies to pulmonary excision where dissection of the individual hilar elements has now almost completely supplanted mass ligature or snare technique. The advisability of performing lobectomy in a free or adherent pleural cavity is not made quite clear, nor are the complications that follow this operation given full consideration, but these are minor comments against the background of well-analysed material. No mention is made of physiotherapy and the specialized breathing exercises which have proved so valuable in all branches of chest work.

The illustrations are satisfactory, consisting of diagrams which amplify technical descriptions and photographs and radiographs relevant to the text. A short bibliography is given at the end of each chapter, but this cannot be regarded as comprehensive. For the general reader interested in many of the subjects discussed, this work will prove of considerable value and affords a suitable contribution to the present state of our knowledge.

The Art of Anæsthesia. By PALUEL J. FLAGG, M.D., New York. Seventh edition. 9 × 6 in. Pp. 519 + xxx, with 163 illustrations. 1945. Philadelphia and London: J. B. Lippincott Co. 36s. net.

FIRST published in 1916, this famous manual has now reached its seventh edition and contains an interesting account of most of the many advances in anæsthesia and analgesia which have occurred in the last three decades.

Dr. Flagg has written this text-book rather as an expression of his personal experience in anæsthesia than as a compilation of contemporary American theory and practice of this specialty. And herein lies the chief attraction of the text, for the author has definite opinions of his own and discusses debatable points with fervour and an ability which verges on the histrionic. His able pen has a rare gift of description, and he uses words seldom seen by English readers, such as the verbs 'to junk' and 'to revamp', which, however, fit the text and make this book eminently readable.

With regard to ether, the author declares that "A personal experience of more than thirty years, with ether as an anæsthetic, has left the author cold to the claims of other agents suggested as basic routines." And later:

"We who are familiar with the use of ether, and conscious of the place which it occupies in the art of anæsthesia, find it difficult to explain the resistance which persists against its universal employment as a basic routine. In spite of the passing popularity of ethylene, the present popularity of cyclopropane, the place which pentothal sodium occupies in selected procedures, ether remains the backbone of general anæsthesia. It carries the burden of relaxation and reflex control. Like an old uncle who has paid for a college education and establishment in practice, but whose manners seem out of date, this benefactor is kept in the background. It is not permitted to appear in the glamorous light of the newcomers. We prefer to be silent, to maintain surreptitious relations with it. What anæsthetic agent, we may well ask, has been treated with the lack of consideration, the gross carelessness accorded ether."

Although few English anæsthetists share this fervid protagonism for ether, we feel that most will agree that the author has written the best chapter on ether anæsthesia extant.

As regards chloroform, although the author does not go so far as the edict of the Committee on Anæsthesia of the American Medical Association, which states: "The use of chloroform as the anæsthetic for major operations is no longer justifiable", yet in his reiteration at the end of Chapter VI he says: "Chloroform, while ideal in efficiency, is a dangerous poison. In the light of present-day pathology, chloroform should cease to be used as an anæsthetic in obstetrics."

Surgeons will be interested in an admirably lucid description of refrigeration analgesia.

There is an interesting chapter on the history of anæsthesia, with excellent illustrations portraying Homer, Du Bartas, William Shakespeare, and Dr. Crawford Long.

Widely read by anæsthetists in the English-speaking countries, this privilege is now extended to Latin America, Dr. Flagg having published a Spanish version of the present edition "as a gesture of goodwill and in token of a sincere and friendly effort at inter-American medical collaboration."

BOOK NOTICES

[*The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.*]

Symposium on Fractures and Dislocations. Reprinted by the United States Office of War Information from the *Surgical Clinics of North America* (Chicago Number) for February, 1945, with the permission of the publishers, the W. B. Saunders Company, Philadelphia and London. 9 × 6 in. Pp. 209 + vi, with 139 illustrations.

Symposium on Neuropsychiatric Diseases. Reprinted by the United States Office of War Information from the *Surgical Clinics of North America* (Chicago Number) for January, 1945, with the permission of the publishers, the W. B. Saunders Company, Philadelphia and London. 9 × 6 in. Pp. 268 + vi, with 44 illustrations.

The Medical Annual, 1945. A Year Book of Treatment and Practitioner's Index. (Sixty-third Year.) Edited by Sir HENRY TIDY, K.B.E., M.A., M.D. (Oxon.), F.R.C.P., and A. RENDLE SHORT, M.D., B.S., B.Sc., F.R.C.S. 8¼ × 5½ in. Pp. 410 + ix, with 47 plates and 61 illustrations in text. 1945. Bristol: John Wright & Sons Ltd. 25s. net.

The Principles and Practice of Rectal Surgery. By WILLIAM B. GABRIEL, M.S. (Lond.), F.R.C.S. (Eng.), Surgeon to St. Mark's Hospital for Cancer, Fistula, and other Diseases of the Rectum; Surgeon to the Royal Northern Hospital. Third edition. 9¾ × 6 in. Pp. 432 + ix, with 11 coloured plates and 237 illustrations, some in colour. 1945. London: H. K. Lewis & Co. Ltd. 45s. net.

Extensile Exposure applied to Limb Surgery. By ARNOLD K. HENRY, M.B. (Dubl.), M.Ch. (Hon., Cairo), F.R.C.S.I., Emeritus Professor of Clinical Surgery in the University of Egypt. 9¾ × 6¾. Pp. 180 + viii, with 127 illustrations. 1945. Edinburgh: E. & S. Livingstone. 30s. net.

Technique in Trauma. Planned Timing in the Treatment of Wounds including Burns. From the Montreal General Hospital and McGill University, by FRASER B. GURD, M.D., C.M., and F. DOUGLAS ACKMAN, M.D., C.M., and collaborators. 10 × 7 in. Pp. 68 + vii, with 17 illustrations and 3 coloured plates. 1945. London: William Heinemann (Medical Books) Ltd. 15s. net.

Duodenal and Jejunal Peptic Ulcer. By RUDOLF NISSEN, M.D., Attending Surgeon, Jewish Hospital of Brooklyn; formerly Professor of Surgery and Head of Department of Surgery, University of Istanbul, and Associate Professor of Surgery, University of Berlin. With a Foreword by Professor OWEN H. WANGENSTEEN. 8½ × 5⅝ in. Pp. 143, with 123 illustrations. 1945. William Heinemann (Medical Books) Ltd. 21s. net.

Tratamiento Pre y Postoperatorio. By F. DOMÉNECH-ALSINA, Ex Associate Professor of Surgical Pathology of the Faculty of Medicine of Barcelona, and J. PI-FIGUERAS, Surgeon, Hospital of Santa Cruz and San Pablo, Barcelona. 9⅝ × 6⅝ in. Pp. 519 × xvi, with 75 illustrations. 1945. Barcelona: Salvat Editores, S.A. Price not stated.